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·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

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LEON GASTER

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EDITORIAL.

In accordance with our usual custom, we take this opportunity to review progress in illuminating engineering during the past year. It need scarcely be said that the war, which is imposing such sacrifices on all sections of the community, has inevitably restricted the efforts of scientific workers in many directions. This time last year, when we reviewed progress in 1914, the country had only experienced a few months of war ; now, a year later, we survey a conflict which has already lasted for nearly sixteen months, and the duration of which is still uncertain.

War conditions have reacted on the lighting industry in many ways. There has of course been an unparalelled demand for certain types of lamps and appliances required for Government and military or naval work. The restrictions of public lighting have been gradually extended and made more strict during the past year, and the memory of this dark period will certainly sink deep into the public mind. In the daily press references to the results of this diminished street-lighting are of almost daily occurrence, and, as we feared from the beginning, the number of accidents, directly or indirectly due to the darkness, must by now have reached a considerable figure. Let us hope at least that the lesson will not be overlooked after the war, that the authorities, through the exceptional experience now gained, will come to recognise the close connection between adequate illumination and public safety, and that in the future the lighting of the streets will be carried out in a more scientific manner.

An event of great importance to the lighting industry—the issue of the First Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops—has recently been fully dealt with in this journal. The appearance of the Report, which is very opportune at the present moment when the factories of the nation are all working at high pressure, should do much to bring home to manufacturers the need for good industrial lighting in the interests of safety, hygiene, and economy. In this field there is ample scope, even in war time, for the services of illuminating engineers. The three volumes issued mark a complete departure, and should be of great assistance to engineers concerned with lighting.

At the Annual Meeting of the Society last May it was pointed out that many of the subjects for discussion during 1915 were of great interest at the present moment, notably those on Searchlights, Visibility, and the Lighting of Rifle Ranges. Another subject—the Rating and Marking of Lamps—has also been receiving attention on the Continent and in the United States.

In the United States, we are glad to see, the Illuminating Engineering Society is actively continuing its work. The proceedings at the recent Annual Convention were as interesting as usual, and the "Code" on Factory Lighting, recently issued, was a useful contribution to the literature on Industrial Illumination.

It was hardly to be expected that any great inventions or discoveries in lighting appliances could be commercially exploited in war time. At the same time it will probably be found at the conclusion of the war that manufacturers have been far from idle.

In this country we have had an opportunity of realising how dependent we formerly were on the Continent for many necessary materials and appliances used in the lighting industry, and we believe that the authorities already recognise how vital to our national existence is the proper encouragement of applied science. In the present critical period, when so great a demand on our men and resources is being made by military and naval requirements, it is the clear duty of the non-combatant section of the population to keep alive the scientific spirit, and to persevere as far as possible in the conduct of scientific research. Such work, although less spectacular, is as necessary for the future welfare of the country as the efforts of those in the field of battle. The wisdom of this view has been officially recognised by the creation of a Committee of the Privy Council now engaged in preparing a scheme to establish a permanent organisation for the promotion of Industrial and Scientific Research. The Committee is aided by an Advisory Council who will advise on proposals for instituting researches, establishing research studentships, &c. We are glad to see that the scheme aims at co-operation with existing scientific and professional bodies, many of whom are now carrying out valuable work in most trying circumstances. We are also glad to note the permanent character of the organisation which, we hope, will constitute a source of encouragement to scientific enterprise and will profoundly influence our industries in time to come.

The Development of Electric Incandescent Lamps in Relation to Illuminating Engineering.

The discussion on this subject opened by Professor J. T. Morris at the last meeting of the Illuminating Engineering Society (see pp. 5—26) brought out several interesting points. Methods of lighting interiors are necessarily affected by the range of candlepower and efficiency of the lamps available, and it is not surprising to find that as a result of the introduction of more powerful and efficient incandescent lamps general over-head lighting is being exploited to a considerable extent in many cases where local lighting with low candlepower lamps would formerly have been used. The rise in intrinsic brilliancy (which according to Professor Morris reaches over 5,000 candles per square inch in the case of the " half-watt " lamp), has made proper methods of shading essential, and given some encouragement to the use of indirect and semi-indirect methods of lighting.

Simultaneously with the greater range in candlepower we find considerable variations in the shape of filament, and several speakers referred to the necessity for careful selection of the lamp to suit the reflector ; in fact, lamp and globe or reflector should be regarded as one " lighting unit." Professor Morris has found that lamps of the " bunched filament " type, having a high powerful downward light component, may prove exceptionally efficient for certain purposes, since they enable a high illumination to be readily obtained on the working plane (naturally at the expense of light, which would otherwise be emitted at other angles). This point is also touched upon in a contribution to the Bulletin of the Swiss Institution of Electrical Engineers, which we reproduce on p. 29. The view is expressed that notwithstanding the apparent gain as regards distribution of light, it seems advisable to aim at producing a standard type of lamp, which can be made cheaper and more reliable, and to modify the distribution of light by using appropriate reflectors. This view would probably commend itself to most lamp-manufacturers. Again, whilst agreeing that the gas-filled or so-called " half-watt " lamps represent a distinct advance in efficiency, we hope that manufacturers will exercise restraint in the introduction of new high voltage and low candlepower units, and that they will make sure that the type is thoroughly serviceable—*i.e.*, that it has a satisfactory life and can be sold at a reasonable price—before it is given to the public. In the case of general lighting with comparatively powerful lamps this is specially important, as the failure of one lamp is not only an item of importance as regards the cost of maintenance but may lead to a section of a workroom being left in comparative darkness.

Another feature of interest at this meeting was the exhibition, by Mr. S. R. Mullard (for the first time in public), of a form of lamp using an incandescent ball of tungsten within a sealed bulb. Although in a sense an " arc " lamp, it requires no manipulation once it is started, and being a close approximation to a " point-source," may have interesting applications for projection work. It is too early as yet to predict the full applications of the lamp, but its appearance at the present moment is a testimony to the enterprise of the Ediswan Laboratories.

Supply Companies and Illuminating Engineering.

The war has imposed difficulties on many companies engaged in the supply of gas and electricity. In manufacturing districts the diminution in the private lighting demand has been, to a great extent, offset by the increased opportunities for heat, light, and power in the factories in the locality; but in other cases, such as the residential districts of London, this compensating advantage does not exist. In addition to the loss in revenue expenses have risen, and it is natural that companies should desire to increase their rates temporarily so as to make good the deficit.

Most people would be willing to agree that such a course may be natural and inevitable in the present circumstances. But from the public standpoint the exact form of the increase is a matter of some moment. In several cases which have come under our notice, we observe that electric lighting companies have not been satisfied with merely increasing their rates, but have taken advantage of the situation created by the war to terminate their old contracts and scale of charges, based on the flat rate, and to substitute other arrangements, which in some cases constitute a hardship to old consumers. Methods which might strike the company as quite reasonable in the present circumstances when applied to new consumers, may be unjust to consumers of old standing; and the welfare of the supply company is inevitably prejudiced if any large section of such consumers feel they have a grievance.

From the illuminating engineering standpoint, it is well known that the best results are obtained by allowing adequate subdivision of the lighting sources, using at each point only the candlepower needed to produce the required illumination, and that ample switching arrangements, enabling only those lamps actually required at any moment to be switched on, are essential for convenience and economy. The system of charging on the total lamps installed, irrespective of the fact that the whole of the lamps will never be in use simultaneously, penalises consumers who adopt proper methods of lighting and encourages parsimony of a very injudicious kind.

We mention this point because it illustrates the importance of supply companies, whether gas or electric, co-operating with the general public and advising them to use their light to the best advantage. Taking a far-sighted view, it is clearly to the interest of companies to do this, and as a result of the work of the Illuminating Engineering Society there are now ample opportunities for their staffs to become familiar with the requirements of good lighting. Companies should, therefore, recognise the benefit of studying these matters, so that their representatives may be in a position to induce existing consumers to exercise a wise generosity in the use of light, taking advantage of the latest developments in electric lamps, and thus raising the status of lighting to a higher level.

We strongly believe that a great deal more might be done by supply companies than at present to interest the consumer in illumination, and to lead him to appreciate that light is a real necessity and not a luxury, and that economy beyond a certain point is inefficient and unwise. At the present time, when there is a great need for discrimination in economy, supply companies have a duty in this respect, and for their own future it is incumbent on them to take much more interest in illuminating engineering than they have done hitherto.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

RECENT DEVELOPMENTS IN ELECTRIC INCANDESCENT LAMPS IN RELATION TO ILLUMINATING ENGINEERING.

(Discussion at a meeting of the Society held at 8 p.m. at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, on Tuesday, December 10th, 1915.

A MEETING of the Society took place at the House of the Royal Society of Arts on Tuesday, December 10th, the CHAIR being taken by Professor SILVANUS P. THOMPSON, D.Sc., F.R.S.

The minutes of the last meeting having been taken as read, the HON. SECRETARY announced the names of new members in the usual way, and the CHAIRMAN then called upon Professor J. T. MORRIS to open the discussion on "Recent Developments in Electric Incandescent Lamps in Relation to Illuminating Engineering." A discussion followed, in which Mr. S. R. MULLARD, Mr. F. W. WILLCOX, Mr. W. R. COOPER, Mr. A. CUNNINGTON, Mr. E. STROUD, and Mr. L. GASTER took part. Professor J. T. Morris intimated that he would reply to the various comments in the Journal of the Society.

The Chairman announced that the next meeting would take place on **Tuesday, January 11th,** when a discussion on **Some Problems in the Lighting of Factories and Workshops, with special reference to the Departmental Report,** would be opened by Mr. J. S. Dow.

Votes of thanks to Professor Morris for opening the discussion, and to Professor Silvanus P. Thompson for presiding, terminated the proceedings.

NEW MEMBERS.

AT the meeting of the Society on December 10th the names of applicants previously read out at the meeting on November 23rd were announced again, and these gentlemen were formally declared members of the Society.

In addition, the following new names were announced :—

Vice-Presidents :—		
	Sparks, C. P.	Chief Engineer of the County of London Electrical Supply Co., *President of the Institution of Electrical Engineers.*
	Young, John.	Chief Engineer of the Gas Works, Hull, *President of the Institution of Gas Engineers.*
Ordinary Members :—		
	Pillinger, G. C.	London Manager, Messrs. R. A. Lister & Co., 47, Victoria Street, LONDON, S.W.

RECENT DEVELOPMENTS IN ELECTRIC INCANDESCENT LAMPS IN RELATION TO ILLUMINATING ENGINEERING.

By J. T. MORRIS.
(Professor of Electrical Engineering at East London College.)

(Introduction to Discussion which took place at a meeting of the Illuminating Engineering Society at the House of the Royal Society of Arts, London, at 8 p.m., on Tuesday, December 14th, 1915.)

MY intention in these introductory remarks is to make a general survey of the recent developments in incandescent lamps during the last few years, particularly as regards range of candlepower and nature of filament; to trace the influence of these developments on the design of shades and reflectors, and on general problems in illuminating engineering.

TABLE I.—SHOWING DEVELOPMENT OF ELECTRIC INCANDESCENT LAMPS.

Nature of Filament.	Date introduced.	Voltage.	C.P.	Watts/C.P.
Carbon	1880	to 100	10—50	5·0
	1889	to 200		
Nernst	1898	110	65	1·5
	1903	250	130	1·5
Osmium	1902	65	35	1·7
Tantalum	1905	to 110		1·9
Tungsten, squirted	1906	to 100	8—50	1·25
	1908	100	6—300	1·25
	1909	230	8—1000	1·25
Tungsten, drawn wire ..	1910	100—250	20—1000	1·25
" Half-Watt "	1913	50—250	750	·65
	1915	25—250	30—3000	·65
Tungsten " Arc Incandescent "	1915	50	100	0·65

Table I. serves to illustrate the gradual development which has taken place in incandescent lamps. Data as regards the range of candlepower, efficiency and date of introduction of various lamps are given from the carbon filament to the " half-watt " or gas-filled lamp, and the still more recent " tungsten arc incandescent " lamp, on which I shall have something to say shortly.

From the figures available it appears that about 75 per cent. of the present lamp output consists of metal filament lamps, and probably it is now only a question of time before the carbon filament lamp becomes practically extinct. It is interesting to observe the great advance made during the last ten years in the range of candlepower available. The introduction of metal filament lamps, giving only a few candles, led to a great development in many portable appliances, such as torches, miners' lamps, and motor-car headlights; while with gas-filled lamps as much as 3,000 candles is now concentrated in a single unit. (In the United States gas-filled lamps, giving as much as 10,000 candles, are said to have been prepared.)

It is also of interest to observe in which countries the various lamps have been developed. The carbon filament lamp was developed partly in the United States and partly in this country; the Nernst lamp in Germany; the Tantalum lamp in Germany; the tungsten lamp and the half-watt lamp partly in Germany and partly in the United States.

The very latest type of lamp on the list, the "tungsten arc incandescent," is to be shown in public for the first time this evening, and is still in the experimental stage. This source might be more correctly described as an "incandescent ball" of tungsten. It is a most interesting novelty, and it is gratifying to observe that it has been developed entirely in the Ponders End Research Laboratory, of the Edison and Swan United Electric Light Co. It is satisfactory to find that, even in the present circumstances, Englishmen have the foresight and determination to attempt and carry to a successful conclusion a research of this kind. The lamp is really an arc in a hermetically sealed glass bulb, and thus combines in many respects the advantages of an arc and an incandescent lamp. The arc is formed between a globule of tungsten and a rod composed of special ionising materials, the globule becoming incandescent, thus forming an approximation to a "point source." From a physical standpoint the lamp behaves like an arc but, being entirely confined within the glass bulb, does not require manipulation by the operator in any way. The specific consumption is about 0.65 watts per candle, but I understand that by forcing up the current 0.32 watts per candle can be attained. The globe is filled with an inert gas such as nitrogen or argon. The tungsten globule, one-tenth of an inch in diameter, is supported on a bi-metallic strip. Immediately above this globule is a rod composed of tungsten and also containing special materials which, when heated by the passage of an electric current, ionise the space between the rod and the ball of tungsten and enable an arc to be struck and maintained. The action of the heat on the bi-metallic strip causes the ball to travel slowly across the filament below it, this movement serving as a protection to the ioniser. The arc itself gives practically no light, the candlepower of the lamp being centred in the tungsten globule. Some tests on the relation between candlepower and voltage gave interesting figures; with a carbon filament lamp 1 per cent. change in current means 5 or 6 per cent. change in candlepower; with metal filament lamps the corresponding variation is less; while with the tungsten "arc incandescent" 1 per cent. change in current causes a change of only about $2\frac{1}{4}$ per cent. in the light.

Table II. summarises some other important properties of electric lamps. It has often been remarked that each gain

TABLE II.—INTRINSIC BRILLIANCES OF ELECTRIC INCANDESCENT LAMPS.

Nature of Filament	C.P. or Watts.	Volts.	W/C.P.	Length. inches.	Diam. mils.	Cross Sectn. "sq. mils."	Proj. Area. sq. in.	Intrinsic brilliancy (c.p./sq. in.)
Carbon	50 c.p.	100	3·5	10·5	12·5	123	0·1312	381
	50 c.p.	200	4·0	13·7	8·7	59·5	0·119	420
Nernst	66 c.p.	95	1·8	0·59	52·4 tube	—	0·031	2150
Osmium	32 c.p.	55	1·9	16·0	4·	12·5	0·062	520
Tungsten	60 w.							
Drawn wire ..	54·5 c.p.	100	1·1	24	2·2	3·8	0·053	1030
	60 w.							
	52 c.p.	200	1·15	36·5	1·3	1·325	0·0475	1095
"Half-Watt" ..	360 w.	80	0·67	20	7·1	39·5	0·072	5000
	1490 w.	240	0·58	—	9	64	0·49	5250
Tungsten "Arc Incandescent" ..	100 cp.	50 (?)	0·65	globule	100	—	0·0078	12900

Tungsten (melting point) ....for comparison 46500
Crater of carbon arc ....for comparison 111000

in efficiency of modern illuminants has been accompanied by a corresponding increase in the concentration of the light so that the intrinsic brilliancy has steadily risen, reaching over 1,000 candles per square inch in the ordinary tungsten lamp. Naturally this high intrinsic brilliancy makes it necessary to shade the filaments from the eye, and has led to the development of greatly improved shades and reflectors. Somewhat variable figures have been given for the still higher intrinsic brilliancy of the "half-watt" lamp, but a recent test in the laboratories of the East London College gives a value exceeding 5,000 candles per square inch, which fully bears out the necessity for proper methods of shading with lamps of this type. As regards the "tungsten arc incandescent lamp" I find the intrinsic brilliancy in this case to be much higher still, namely, 12,500, which is ten times that of the ordinary tungsten lamp. For the sake of comparison the intrinsic brilliancy of tungsten at its melting point, 46,500, and the positive crater of the arc between carbon electrodes, 111,000 candles per square inch are also included in the table.

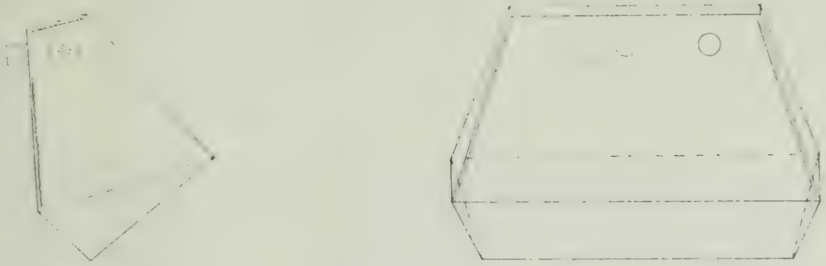
(NOTE.—Figures relating to the Osmium lamp have been added to these tables at the suggestion of the Chairman.)

In passing it is worth notice that high intrinsic brilliancy, which is inconvenient for purposes of illumination, is exactly what is needed for certain branches of optical work, *e.g.*, for cinematograph and optical projection and for searchlights. In this case we want the nearest approach to a point-source, and the "enclosing area" of the filament, besides its intrinsic brilliancy is also important. The best results are obtained from a small spot of light of intense brilliancy, and it is well recognised that the crater of the carbon arc has hitherto surpassed all other sources in this respect. By using closely packed filaments of spiralised drawn wire the desired conditions can be approached, but in these circumstances the source is not really a "point," but a complicated series of lines which reveal themselves in optical projection. The new "tungsten arc incandescent," on the other hand, consists of a continuous glowing surface, and it will be interesting to see whether this will have important applications for projection work.

(In order to illustrate the difference in the arrangement of filament in various lamps the lecturer at this stage projected on the screen the filaments of a number of actual lamps, including the new "tungsten arc incandescent" lamp.)

Apart from their special applications for projection purposes in motor-car headlights, lanterns, &c., it is of interest to inquire whether the close-packed spiralised filaments are not more advantageous, with a view to better distribution of light with modern reflectors. With the ordinary straight filament a great deal of light is emitted horizontally, and this light must be subsequently directed downwards by reflectors. But with some forms of spiralised filament lamps, the percentage of light emitted immediately below the reflector is much greater, and the downward illumination obtained with well-designed reflectors is much increased. If shades of a decorative kind, which have little directing power, are desired, the advantage of using lamps whose filaments are constructed to give a strong downward component is possibly even greater. From my own experience the life of such filaments appears to be somewhat less, perhaps 20% less, than those of the straight type, but in most cases the cost of replacing lamps is more than counterbalanced by the gain in illumination, and the smaller consumption to produce a given effect.

It will be observed that the distribution of light from many lamps with coiled filaments is radically different from that of the ordinary standard type of lamp—a point that was brought out very clearly in the contribution by Mr. Willcox last March. It is a question what is meant by the "candlepower" usually ascribed to such lamps. The candlepower of an ordinary lamp is usually measured perpendicular to the axis of the straight filament, but even this value bears little relation to the performance of the lamp when the distribution of light has been entirely altered by using a suitable reflector. It is worth the consideration of lamp-manufacturers whether they could not provide a rough polar curve with each lamp sold, the curve being marked on the paper in which the lamp was wrapped.



SECTION. ELEVATION.

Corrugated reflector surface.
——— Plain reflector surface.

FIG. 1.—Details of overhead reflectors for platform lighting in the Queen's Hall, People's Palace.

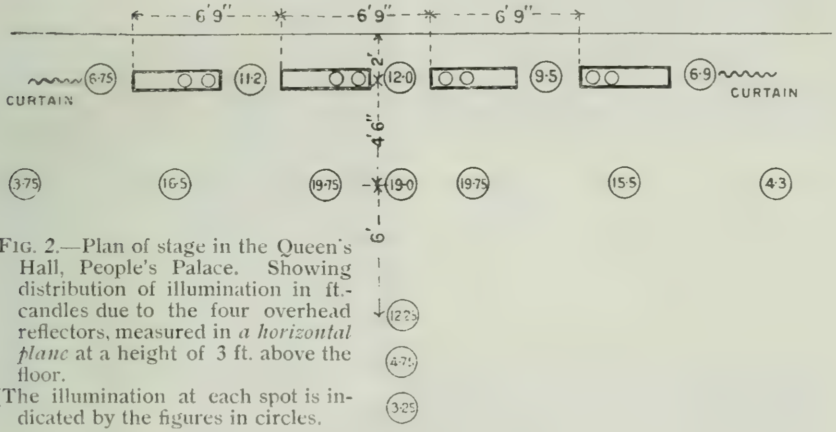


FIG. 2.—Plan of stage in the Queen's Hall, People's Palace. Showing distribution of illumination in ft.-candles due to the four overhead reflectors, measured in *a horizontal plane* at a height of 3 ft. above the floor.
(The illumination at each spot is indicated by the figures in circles.

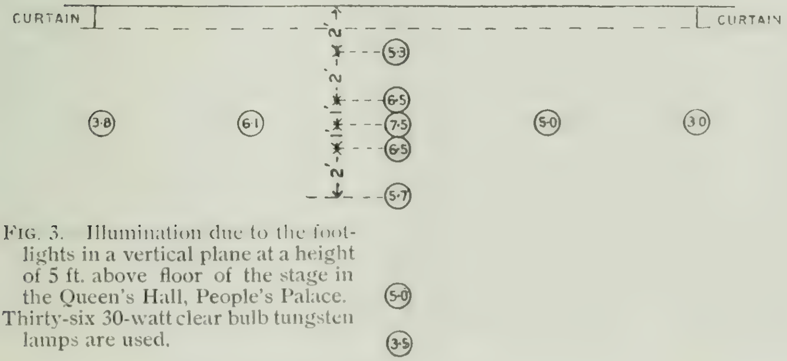


FIG. 3. Illumination due to the footlights in a vertical plane at a height of 5 ft. above floor of the stage in the Queen's Hall, People's Palace.
Thirty-six 30-watt clear bulb tungsten lamps are used.

No doubt this would mean more trouble, but would give a much more definite idea of the performance of the lamp to the purchaser.

Another point for consideration is the design of reflectors to suit special types of filaments. At present manufacturers appear to design the reflectors to suit the ordinary straight filaments. It is obvious that the position of the filament with regard to the reflector will affect the polar curve of the lighting unit, and it would be a great advantage if makers of lamps and reflectors could co-operate more completely so as to secure that standard and suitable dimensions, for both are adopted. With a straight filament errors due to the position of the filament are probably not very great. But with a filament of the bunched type the polar curve is very different, and a small change in the position of a filament of this kind has much more effect. Those who have used lamps having portions of the filament mounted horizontally know that the distribution curve often varies considerably during the life of a lamp owing to the "sagging" of the filament. The most important factor for most installations is a knowledge of the illumination obtainable 5 or 6 feet below a given unit, consisting of a certain lamp in a specified type of reflector, and it would be a convenience if this could be generally stated.

In what follows I propose to describe a few lighting installations which have been carried out under my supervision at the East London College and elsewhere, and which illustrate the application of lamps having various kinds of filaments, in some cases used with specially designed reflectors.

Figs. 1—6 illustrate the special arrangements made for the lighting of the stage in the Queen's Hall at the People's Palace. The stage receives illumination from footlights and also from four special reflectors, in the design of which Mr. Wise, a member of the Society, rendered valuable assistance. The chief points of interest may be summarised as follows :—

PARTICULARS OF SPECIAL LIGHTING OF STAGE OF QUEEN'S HALL, PEOPLE'S PALACE.

Requirements :—(1) Fifteen feet clear head room. (2) Lights to be entirely invisible to the audience. (3) No light to escape over front of stage, and (4) Lighting units to be supported independently of any other fitting on the stage.

Useful area, 28 feet × 14 feet.

Lighted by 4 units, each consisting of a specially designed reflector containing one 600 watt clear tungsten and one 300 watt clear tungsten lamp. A section and elevation is shown in the accompanying plan (see Fig. 1).

Height of light source, 17 feet above stage.

Resulting illumination shown in detail on accompanying plan (see Fig. 2).

Average, 13 foot-candles.

Maximum, 20 foot-candles.

Minimum, 7 foot-candles.

Reflectors are practically invisible to the audience.

Illumination on a vertical surface is given for the footlights (see Fig. 3).

Photographs of the Hall are also shown.

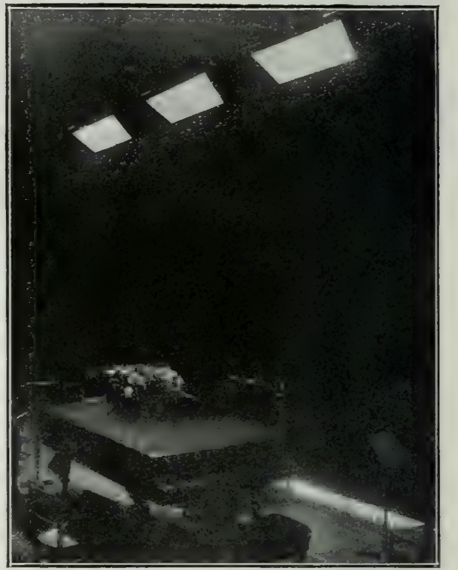


FIG. 4.—Photograph of portion of stage (Queen's Hall, People's Palace), showing overhead reflectors for platform lighting.

I may mention that the special design of the above mentioned reflectors was made necessary by the fact that only lamps with ordinary filaments occupying a considerable space were available. Had half-watt lamps been available the design might have been simplified.

The next illustration (Fig. 7) shows the electrical engineering laboratory, which is lighted by bunched filament lamps in Holophane reflectors. The original lighting was by means of vertical filament lamps, but by substituting bunched filament lamps (the lamp in each of the eight fittings being changed from an ordinary 100-watt tungsten to a 60-watt "axial" tungsten lamp), a much better result has been obtained.

The drawing office of the Electrical Engineering Department, East London

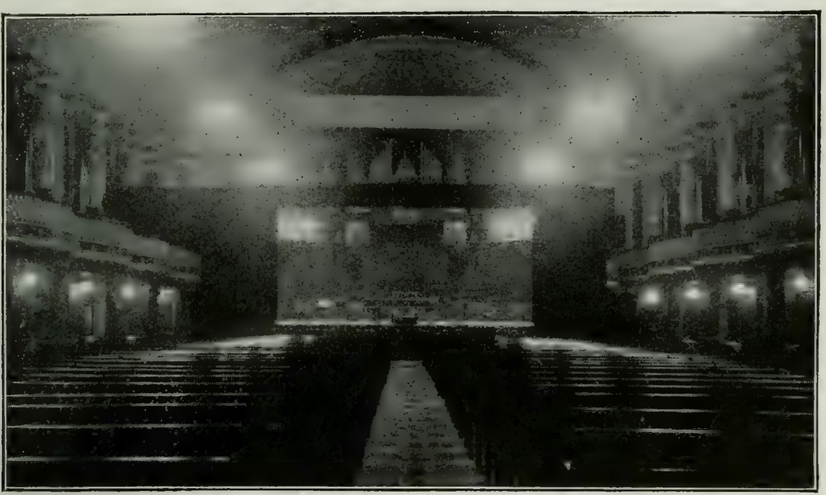


FIG. 5.—Queen's Hall, People's Palace, showing effect of general lighting; special overhead platform reflectors *off*.

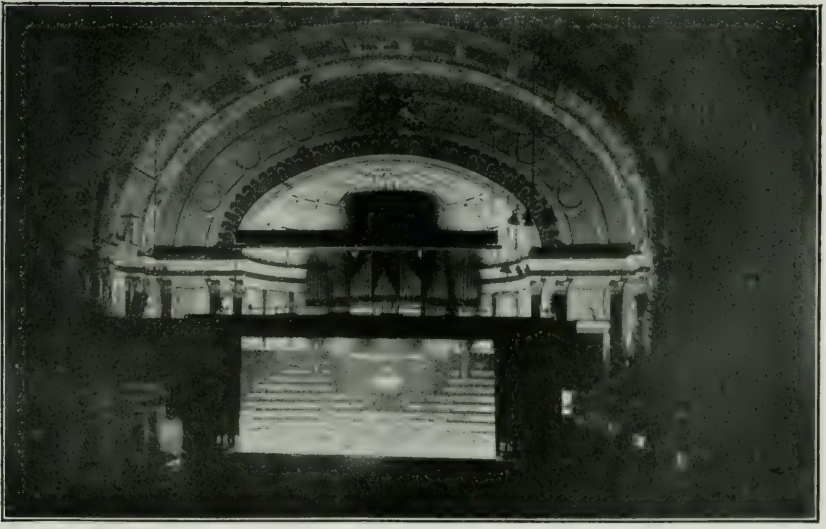


FIG. 6.—Queen's Hall, People's Palace; general lighting *off*. Special overhead platform reflectors and footlights *on*.

College, illustrated in Fig. 8, again shows the use of bunched filament lamps in Holophane reflectors.

The following particulars of this installation serve to show the advantage of this type of lamp :—

Particulars of Lighting of Drawing Office, Electrical Engineering Department, East London College.

Room measures 42 feet 24 feet.

Original System of Lighting :—Lighted by twenty 60-watt lamps, with Holophane shades.

Centre of each source of light 7 ft. above tables.

Horizontal illumination in working area, 4·0 to 6·5, with one watt for square foot.

Final System of Lighting :—Altered to spiral filament tungsten lamps and sources raised.

Twenty 40-watt lamps.

Centre of source of light raised to an average of 7 ft. 6 in. above tables.

Horizontal illumination in working area at table height 7·0 to 8·5 foot-candles, with $\frac{3}{4}$-watt for each square foot.

I have had similar experience in an exceptionally large chemical laboratory where a similar diminution in the consumption was made. In view of these results it is surprising that lamps of the bunched filament type are not more widely used, and that thoroughly appropriate reflectors for use with them are not available.

The final illustration (Fig. 9) shows a specially designed method of lighting a chemical balance. At my suggestion this method has been adopted by Messrs. Gallenkamp, who kindly lent a balance for exhibition at this meeting. A tubular lamp in an appropriate reflector is placed on the top of the balance strongly illuminating the interior. A shallow screen of a white matt material (cardboard or celluloid) near the top of the balance serves to conceal the filament from the observer, and also assists in diffusing the light on to the wider beam. The observer sees the strongly illuminated scale immediately below the lower level of this screen. At the base of the balance there is also an inclined sheet of white cardboard. This serves to reflect light on the marked surface in front of which the pointer attached to the beam oscillates ; the observer can thus see at a glance whether or no the beam is in exact balance. In view of the delicacy of the operations carried out on a chemical balance, and the time spent in these operations, a good local illumination from a concealed source is really helpful, and the above method may serve as an instance of how by the choice of the best type of lamp and appropriate screening devices, one can secure exactly the conditions of illumination which the problem demands.

The photograph hardly does justice to the actual condition, since the brilliantly illuminated scale arm was necessarily somewhat over-exposed, and is in reality much brighter than the picture suggests.

In conclusion, I regret that these remarks are somewhat disjointed in character. This is due to the fact that I have been extremely busy on other pressing work during the past months, and, like many other members of the Society, have not had as much time to devote to illumination as I would like. I hope, however, that enough has been said to lead to a useful discussion. I would also like to express my indebtedness to Mr. Mullard for enabling me to exhibit the new lamp with which he is associated and for other information ; and to Mr. Dow, the Hon. Asst. Secretary of the Society, by whom the various photographs illustrating this contribution were taken.

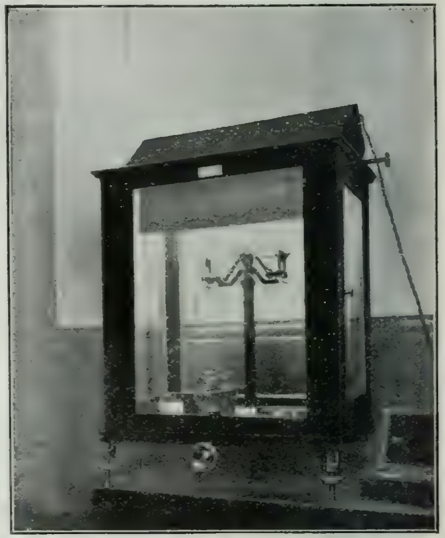


FIG. 9.—Showing special lighting of chemical balance.

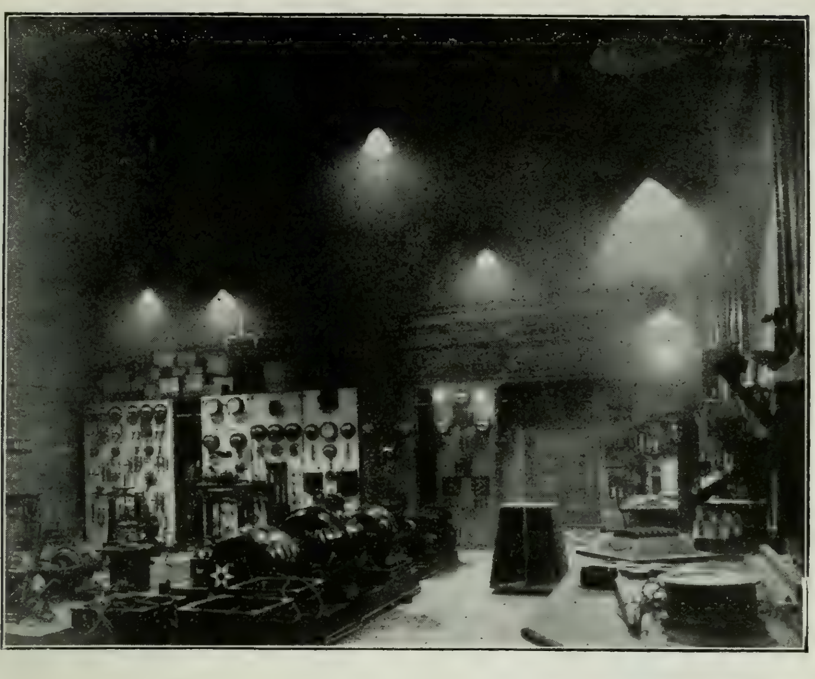


Fig. 7.—Illumination of Electrical Engineering Laboratory, East London College.

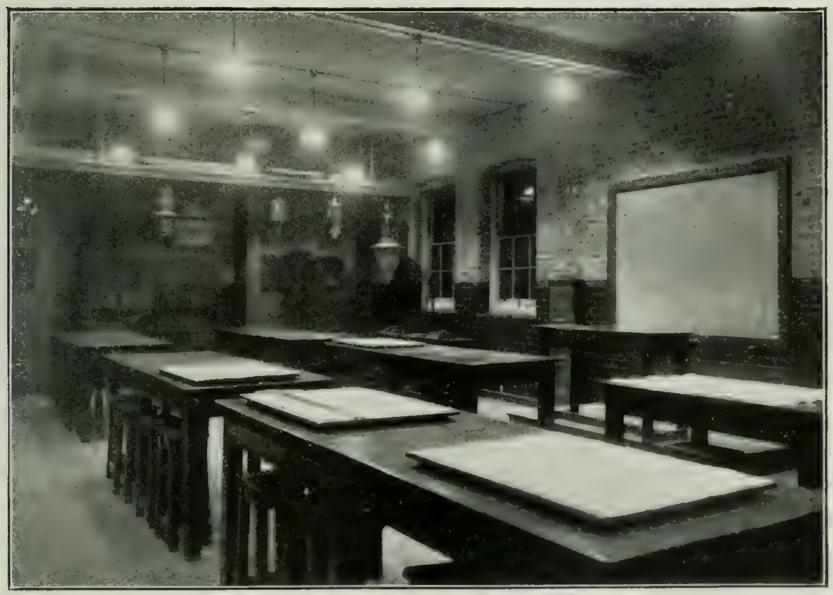


FIG. 8.—Illumination of Drawing Office, East London College, by special bunched filament lamps in Holophane reflectors.

DISCUSSION.

Mr. S. R. Mullard exhibited and demonstrated the arc incandescent lamp referred to by Professor Morris. The ionising rod mentioned by Professor Morris, he said, is a mixture of tungsten and some of the refractory earths.

The type of lamp suitable for continuous current circuits, where about 100 mean spherical candle-power was required, was as shown in Fig. (1). It would be seen that in appearance the new lamp was similar to the ordinary incandescent lamp, the bulb, stem and leads being similar in both types.

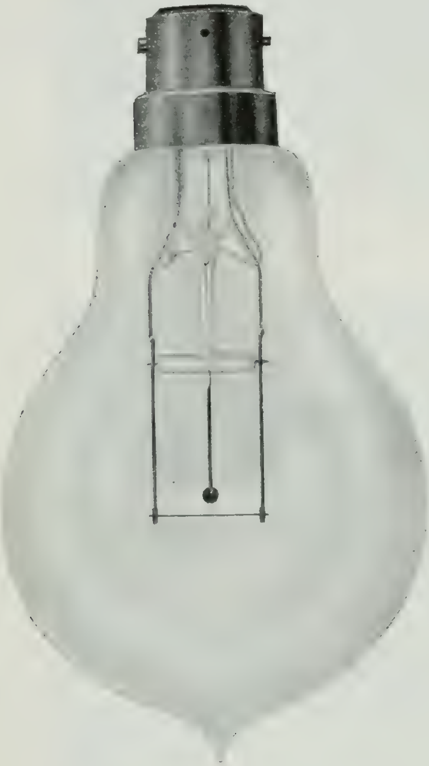


Fig. 1.—General view of Lamp.

The lamp consisted of a nitrogen filled bulb, in which were mounted a spherical tungsten electrode and an ionising rod. Between the electrode and its stem lead an expansion strip was inserted.

Three leads were necessary through the lamp stem; on one was mounted the spherical electrode, whilst the other two supported the ionising rod. There were three contacts in the lamp cap, which had odd sized pins, and a three plunger lamp holder, having large and small slots, was employed. This prevented wrong connections between lamp holder and lamp cap. Fig (2) showed diagram of connections for the lamp. The positive main lead was divided into two circuits, one passing through the resistance R_1, and the push or normally off switch E. to the one end of the ioniser, the other circuit being through the resistances R_1 R_2 to the electrode A. The negative lead was connected to the other end of the ioniser.

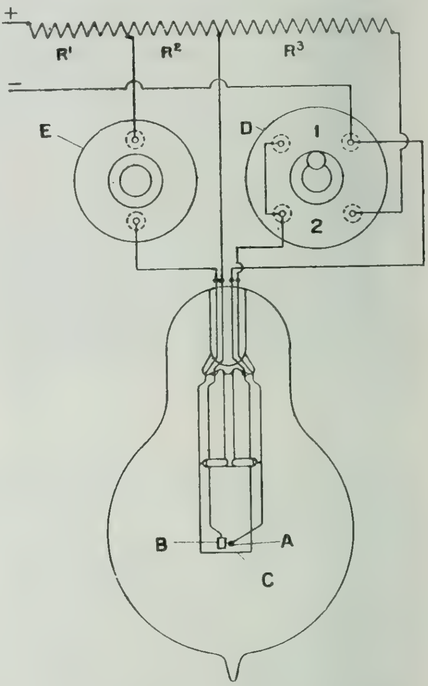


Fig. 2.—Showing arrangement of tungsten globule, ionising filament, and resistance for tungsten arc incandescent lamp.

To start the lamp, the switch E. was depressed, and current passing through the ionising rod caused this to incandesce and ionise the surrounding gas. The switch E. was quickly released, contact only being made for a second or two, and on the ioniser circuit being broken an arc was struck between the electrode A. as anode and the ionising rod C. as cathode. The heat from the arc caused the expansion strip F. to warp and move the arc to a position further along the ioniser. At this point where the arc was maintained, the ionising properties of the rod were destroyed, but on switching off the current, the expansion strip cooled, and the spherical electrode returned to its original position opposite the still active portion of the ioniser.

By this means the lamp could be started at any period of its life without difficulty. In this lamp practically the whole of the intense white light emanated from the small globule of tungsten A., which was about 1/10-inch in diameter.

For high candle-power lamps, where a larger light giving surface was required, the arrangement was as shown in Fig. (3).

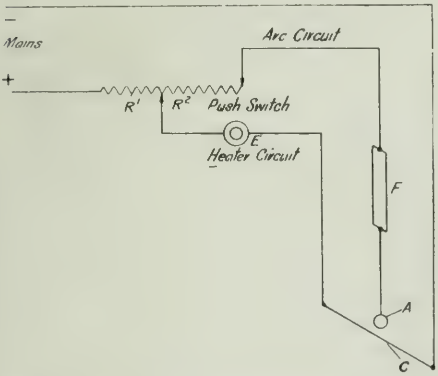


FIG. 3.—Diagram of connections for high c.p. arc incandescent lamp.

In this lamp there were two electrodes, the small spherical electrode A., and a larger flat electrode B., both of fused tungsten. These were set at a definite distance from each other and from the ioniser C.

To start the lamp, the 2-way switch D was made to complete the circuit 2, thus connecting the electrode A. to the positive lead through the resistances R_1 R_2 R_3. On pressing the push or normally off switch E. (which was connected to the positive lead at the end of the resistance R_1) the ioniser C. was made to incandesce sufficiently to ionise the gas between it and the electrode A. Two or three seconds, during which the ioniser was incandescent, was sufficient to accomplish this. Immediately the switch E. was released and the positive lead of the ioniser circuit broken, an arc was struck between the ioniser C. as cathode and the small electrode A. as anode. As soon as the electrode A. became brightly incandescent the switch D. was moved into the position at I. The electrode A., formerly positive, now became negative, and being white hot easily ionised the gap between itself and the plate electrode B. (connected to the positive main lead through the resistances R_1 R_2). An arc was thus struck between the spherical electrode A. as cathode and the plate electrode B. as anode. By these means it would be seen that an arc could be easily struck between substantially large tungsten electrodes, which being properly proportioned ensured the lamp having a long life.

Lamps of this type had been made in the Edison and Swan Laboratory up to 1,200 candle-power.

A spectrum analysis of the light emitted showed continuity and strength in the visible, also an extension into the ultra-violet.

The new lamp was a great advance on the ordinary carbon arc. No regulating mechanism was required and, therefore, the initial cost of production was less. The arc was very stable on varying voltage, and further there was no trouble from flickering or arc wandering. The arc being completely enclosed there was no danger from fire. The light giving surface for the same output was greater than that of the carbon arc, and the loss of light due to obstruction by the electrodes was much smaller.

In comparison with incandescent lamps, the light from the new lamp was much whiter in colour than the ordinary half-watt lamp. The lamp had special applications for all types of projection lanterns, micrography, colour matching, &c., &c.

(For a fuller account of the physical and electrical characteristics of this lamp, see *Journal of the Institution of Electrical Engineers*, Vol. 34, No. 251, Dec. 1st, 1915.)

Mr. F. W. WILLCOX referred to the change in designs and change in character of fittings which the new development in lighting, especially the half-watt lamp had rendered necessary, but before giving these he would like to say something with regard to Professor Morris's advocacy of the spiralised filament lamp. Professor Morris and himself had exchanged views on this matter before privately, and apparently Professor Morris believed very strongly in this lamp. His own experience in connection with it, however, had been that it would not generally prevail, for the very obvious reason that it was more or less a special lamp. The ordinary vertical filament had the distinct advantage that it was a uniform type of filament for practically all sizes and types of lamps. The straight filament also enabled the bowl form of reflectors to be used more advantageously, and the distribution of the illumination could be insured very much more positively than with such a spiralised concentrated filament form of lamp. As long as the efficiency was not improved the straight filament holds the field. The greater intrinsic brilliancy of the half-watt lamp was justified by the change in the efficiency, but with the spiralised filament vacuum lamp there was no gain in efficiency; indeed, the actual efficiency was lower than for the ordinary lamp. Further, being a spiralised filament it was bound to be much hotter, and consequently the life would be shorter.

He could not understand how it was that Professor Morris had secured a better illumination with 40-watt spiralised filament vacuum lamps than with a 60-watt straight filament vacuum lamp. There could not be a greater total illuminating effect, and he could only explain it on the basis that Professor Morris had merely increased the downward light by the type of reflectors that he used. While it was not possible to increase the total light, it was possible to increase the light in some particular direction. However useful these lamps might be in special cases, they were not lamps which would be universally used as against straight filaments because of the extra cost, shorter life, and other disadvantages such as their extreme brilliancy, which made them difficult to use under ordinary conditions. If, however, there was some gain in efficiency as in the half-watt lamp, then the change in the type of filament was justified, and this brought him to the subject of his notes dealing with the changes which the half-watt lamp had brought about in reflector and fitting design.

It was fortunate from the illuminating engineering standpoint that the new half-watt lamps had all the qualities which rendered ordinary incandescent lamps the most convenient type of lamp to manipulate.

These advantages might be summarised as follows:—

(A) There are no moving parts or mechanism, and the half-watt lamp neither requires nor permits adjustment.

(B) The half-watt lamp is supplied and used as a complete article without separate parts.

(C) The half-watt lamp is equally satisfactory on either alternating or continuous current service, and for series or multiple operation.

(D) The half-watt lamp is serviceable on all frequencies of alternating current down to and including 25 cycles.

(E) The half-watt lamp is a non-inductive load (power factor 100 per cent.).

(F) The half-watt lamp is available for any voltage from 25 volts to 260 volts.

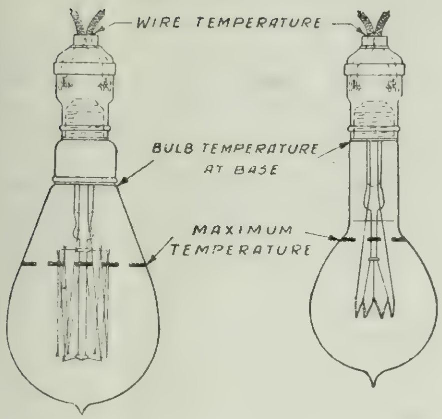
(G) The half-watt lamp is made in a complete range of sizes, from 15 watts to 1,500 watts, permitting the use of a number of distributed lights in place of large arc light units of equivalent candle-power, a condition securing the ideal for uniform lighting.

(H) The half-watt lamp can readily be adapted in reflectors of suitable design to secure any desired distribution or concentration of light, especially in the lower hemisphere, and the filament of the lamp is shaped so as to materially promote this feature.

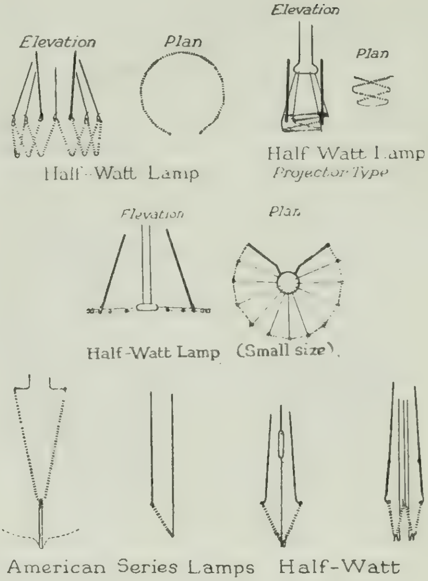
(I) The light of the half-watt lamp is steady, soft, uniform, and of a most brilliant quality and satisfactory colour.

(J) The half-watt lamp is silent, simple, and reliable, and relatively to other high candle-power lamps is inexpensive in investment or first cost.

The introduction of the new half-watt tungsten lamps will compel a radical change from the old lighting methods. The very high intrinsic brilliancy of these lamps (some eight-fold greater than that of the ordinary tungsten lamp) will enforce proper methods of obscuring and diffusing the light, as the light in general



Showing distribution of temperature in ordinary (vacuum) tungsten lamps and half-watt (gas filled) lamps.



Types of half-watt lamp filaments.

TABLE, COMPARING TEMPERATURES DEVELOPED IN ORDINARY TUNGSTEN AND GAS FILLED ("HALF-WATT") LAMPS, AS DETERMINED IN THE ENGINEERING DEPARTMENT, NATIONAL LAMP WORKS, U.S.A.

Lamp Wattage.	Minimum Bulb Temperature in Degrees Fahrenheit. Room 70°.	Bulb Temperature at Cap in Degrees Fahrenheit. Room 70°.	Type of Lamp Holder, and Wire Temperature in Degrees Fahrenheit. Room 70°.
Metal Filament Lamps :—			
Vacuum Type :—			
100	152	105	Standard brass E.S. holder.
150	157	120	Brass holder.
250	245	140	Brass holder.
"Half-watt" Type :—			
100	223	110	Standard brass E.S. holder.
200	265	150	Brass holder.
300	260	104	Porcelain Goliath holder.
400	327	164	Do.
500	360	175	Do.
750	317	170	Do.
1000	353	190	Do.

is too painful to be used exposed in the objectionable and harmful way in which the ordinary tungsten lamps are so frequently employed. In a sense, therefore, the new half-watt lamps will prove an excellent aid to the cause of illuminating engineering and good lighting methods. We have at last come to a type of incandescent lamp which does not permit being substituted for existing lamps in the old style fittings and reflectors as the ordinary tungsten lamp was, when it replaced the carbon lamp. There will, therefore, be a very radical change from the old methods and existing antiquated types of shades and appliances, and the substitution therefor of new scientific equipment, designed for use with these latest lamps.

The large gains in efficiency secured by these new lamps will of necessity cause their very wide adoption, particularly in industrial plants. We are therefore face to face with a revolution in lighting appliances and methods. These can in general be stated as follows :—

(A) The raising of the plane of illumination to 10 or 12 feet above the working plane—thus approaching more equally daylight conditions, by the employment largely of general illumination instead of purely local illumination with the old methods of drop cords or hand lamps.

(B) The obsolescence of the ordinary arm fitting or electrolier or chandelier, which is a relic of the old gas or oil flame days. The art of illumination will thus be freed from the trail of the fittings industry with its large masses of metal in more or less inartistic groupings of arms and branches, and the opportunity given of substituting the more pleasing and beautiful form of bowls or spheres or dishes and urns of alabaster or attractive diffusing glass ware.

(C) The obsolescence of the old ordinary conic opal (open mouth) shade. This particular appliance is the *bete noir* of illuminating work throughout Great Britain, and the half-watt lamp is conferring a blessing of marked degree in banishing this uncouth, inefficient appliance which obstructs and mars the inside of most of the offices and public buildings and other interiors in Great Britain.

(D) The adoption of some form of bowl or dish fitting of translucent glass (semi-indirect lighting) or an opaque bowl (indirect lighting) to distribute and diffuse the light and screen the direct rays. The beauty, comfort, and general agreeableness and effectiveness of indirect and semi-indirect lighting becomes generally available through the high efficiency and volume of light, of these new half-watt lamps. In brief, the half-watt lamp enables us to approach the daylight conditions by the wider employment of that general illumination which indirect and semi-indirect lighting gives.

(E) As the half-watt lamp is employed in large sizes, 100 watt and over, and is more efficient in the still larger sizes of 300 watt and over, there will be a tendency to eliminate " cluster lighting," groups of small lamps, the arm fitting, &c., which will be replaced by a single lamp of suitable size in the proper design of equipment of bowl or dish.

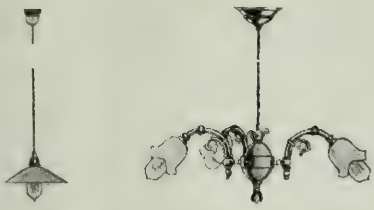
(F) Furthermore, the ordinary open flame arc lamp and enclosed arc lamps to a great extent will be supplanted by the new half-watt lamp, owing to the decided advantages of simplicity, general adaptability and freedom from care and attention which the half-watt lamp secures.

Certain specific changes in design have been occasioned by the coming of the half-watt lamps, namely :—

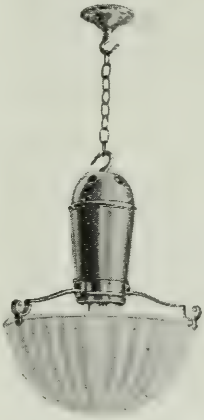
(1) The greater concentration of the light-source in the form of a more compact filament, subtending a much smaller vertical angle than the ordinary filament, requires that :—

> (A) Greater care and skill must be expended on the design of reflecting surfaces in order to ensure that the desired distribution curve is obtained.
>
> (B) The position of the filament with regard to the reflector needs to be determined more accurately than in the case of an ordinary filament as a slight displacement up or down makes a much greater difference ; to meet this requirement an adjustment enabling the lamp to be moved up and down to its correct position is needed and is embodied in modern types of reflectors.

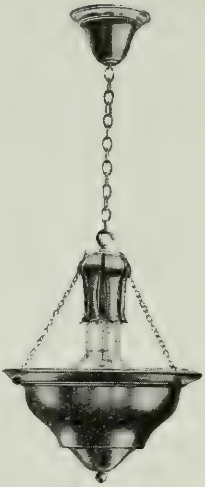
(2) The heat generated in the half-watt lamp is exceptionally great, partly owing to the larger volume of energy concentrated in a given space, and partly to the fact that the gaseous contents of the bulb conduct the heat very readily to sur-



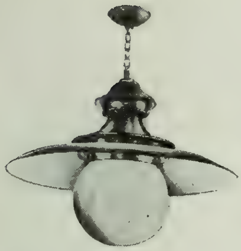
(a) Types of old fashioned fittings which the half-watt lamp has caused to be superseded by improved scientific designs of fittings, such as the following.



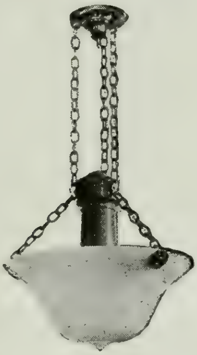
Semi-indirect fitting.



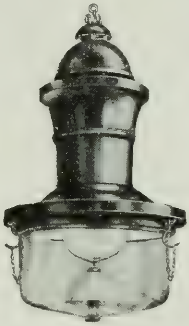
Indirect lighting fitting.



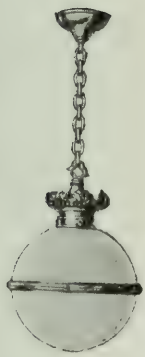
(b) Ball fitting with over reflector.



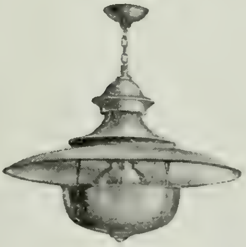
Semi-indirect fitting with ornamental bowl.



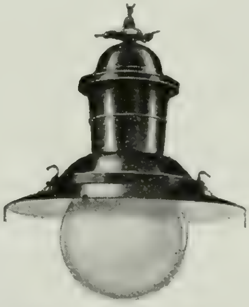
Street Lighting fitting.



(c) Sphere fitting.



Semi-indirect fitting.



Weatherproof Lantern.

A FEW EXAMPLES OF MODERN FITTINGS FOR HALF-WATT LAMPS.

(Mr. F. W. Willcox).

rounding objects. Special provision must therefore be made for ventilation, and the wiring must be carried out with heat-proof insulation. The concentration of heat at the neck of the bulb makes it imperative that all outdoor fittings should be weatherproof, as well as adequately ventilated.

(3) As a general rule half-watt lamps must be burned in a pendant position, and fittings must be designed accordingly. (An exception may be made in the case of some of the smaller sizes which utilise filaments shaped in a horizontally situated ring; these may be burned upside down).

(4) The concentration of light in a smaller filament has increased the difficulties of design in certain types of reflectors. An instance is afforded by the special extensive reflectors designed for street lighting; it is very difficult to design a suitable reflector of this kind for the half-watt lamp, and recourse must be had to the use of a deflector under the filament or to a special refracting globe (such as the Holophane refractor) in order to secure the high component at a small angle below the horizontal.

(5) The greater concentration of filament, besides making shading necessary in order to diminish the high intrinsic brilliancy, also gives rise to harsher shadows; for this reason also suitable methods of diffusing the light are needed.

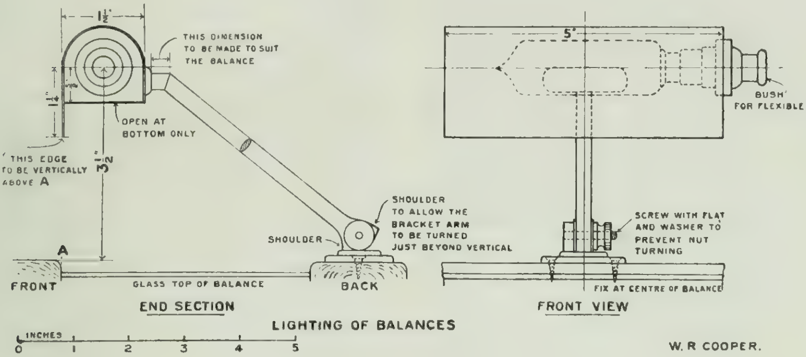
The design of lighting units to comply with all these requirements is no easy matter. In general the increased efficiency of the half-watt lamp should result in a diminution in the size and bulk of the fitting for a given output of light. In particular it should be noted that the development of this type of lamp means a new era in illumination, and must give rise to new methods. Just as " new wine cannot be put into old bottles," so these new lamps cannot be effectually used with old types of fittings. New units are being introduced, and the methods employed in lighting various classes of interiors must undergo considerable modification. At the present time, when the publication of the Home Office Report on Factory Lighting has emphasised the economic and hygienic value of good illumination, these new appliances should be a valued weapon in the hands of the illuminating engineer.

Mr. W. R. COOPER expressed the hope that Mr. Mullard would be able to give a few more particulars of his lamp, and some further statement of the advantages as compared with the ordinary incandescent lamp. The latter required stating a little more fully because it was a more complicated lamp; he would like to know, for instance, how high the candle-power could go, and what the life was likely to be. Intrinsic brilliancy was a difficulty in gas filled lamps. Would it be possible to include a reflector of unglazed porcelain above the filament in the bulb without seriously interfering with the maintenance of a good vacuum? If so, this would give relief. A polar diagram of a lamp by itself would be of very little value because lamps are always used with reflectors.

Probably the proper course would be for the makers to develop certain reflectors which they considered satisfactory, and to supply polar diagrams of the lamp and reflector. In that way people would know what they were getting, and the sort of shade they should use.

He was interested in Professor Morris's remarks as to platform lighting, and particularly in regard to balance lighting. He himself had recently designed a fitting for lighting chemical balances, and this appeared to him simpler than Professor Morris's method. As seen by the accompanying drawing a small tubular lamp (which might have to be a carbon lamp for the higher voltages) was used in a metal shade. The shade was closed at either end, and was carried down a certain distance in front so as to screen the lamp entirely from the eyes. The shade was conveniently made of bright lacquered brass, and one end of it carried the lamp holder. Since heating of the balance must be avoided in accurate work the shade was carried by a bracket at the height shown, and might be ventilated. The bracket was hinged so that it could be thrown back and thus cause no obstruction to daylight working. By having the shade in the position indicated perfect illumination was obtained of both the beam and the lower scale without the necessity of any reflecting surfaces within the balance case. He thought it was undesirable to introduce such reflectors if they could be avoided.

Mr. A. CUNNINGTON (L. & S.W. Railway Co.) said he had hoped that Professor Morris would have given more particulars in connection with half-watt lamps, such as mean spherical candle-power and candle-power in certain directions. Possibly a polar curve might be of use although as Mr. Cooper had pointed out it would not be of much value if it only referred to the lamp and not to the reflectors. There seemed to be much doubt as to exactly what candle-power was referred to in rating half-watt lamps. He would like to know if the efficiency of 0·65 watts per candle for the half-watt lamp in the table shown by Prof. Morris was based on the mean spherical candle-power, the mean hemispherical, the vertical or the horizontal. Another point was the question of under-running half-watt lamps. The relationship between voltage and life was said to be such that very slightly over-running the lamps considerably shortened the life, and in actual practice he had found this to be so. Owing to fluctuations of voltage, certain lamps under his control had had to be renewed very frequently, the reason being the close proximity of an anti-aircraft searchlight installation which had caused the pressure of supply to be very erratic. With half-watt lamps one could not afford to look upon cost of current as the only thing of importance. Maintenance was a very serious matter when each lamp cost a sovereign, and in order to guard against the loss of a lamp through a temporary rise in voltage, it appeared to be worth while actually to under-run slightly even if the maximum efficiency was not obtained. There was obviously a theoretical point of maximum economy in the running of lamps, with a given price for current and renewals, and possibly Prof. Morris could throw some light on this subject.


1½"
THIS DIMENSION TO BE MADE TO SUIT THE BALANCE
OPEN AT BOTTOM ONLY
THIS EDGE TO BE VERTICALLY ABOVE A
3½"
A
SHOULDER TO ALLOW THE BRACKET ARM TO BE TURNED JUST BEYOND VERTICAL
SHOULDER
FRONT
GLASS TOP OF BALANCE
BACK
END SECTION
5"
BUSH FOR FLEXIBLE
SCREW WITH FLAT AND WASHER TO PREVENT NUT TURNING
FIX AT CENTRE OF BALANCE
FRONT VIEW
LIGHTING OF BALANCES
INCHES
0
1
2
3
4
5
W. R COOPER.

Mr. E. STROUD said he had listened to Professor Morris's remarks with great interest.

He failed to see the advantages of lamps with their filaments so designed as to throw the light downwards without the aid of a reflector, as, whilst this form of lamp gives a greater candlepower than the straight form of filament directly under the lamp, it must of necessity give a corresponding value directly above, which to a great extent cannot be collected by reflectors and utilised in an efficient manner, being lost in lamp-cap and fitting.

It is generally agreed that one must use some form of reflector with any lamp to obtain maximum efficiency and avoidance of glare, and the best form of filament is one which enables the reflector to collect the majority of the rays above the 60 degree zone, which otherwise would be wastefully employed.

Professor Morris also stated that the new spiral wound filaments similar to the "half-watt" types altered the characteristic distribution of existing reflectors now on the market. This is not the case (at least with Holophane Reflectors), as with the smaller size of filaments the curves with the reflectors are accentuated to a marked degree, but are not altered in general character. That is to say an E, I or F type of reflector remains of the same type, and the spacing is unaltered.

As light sources get more concentrated (or smaller) so will it be possible to get still more efficient reflection with prismatic glassware.

To get these curves one must necessarily make suitable modifications in holders and galleries, and insure the correct position being taken up by filament to reflector. He quite agreed with Mr. Willcox that the position of the filament in relation to the reflector with the new form of winding is of much greater importance than it was with the old straight type. Any steps that could be taken in the direction of standardising lamps so as to make the position of the filaments uniform would be a great advantage.

Mr. Willcox mentioned that the smaller sizes of bulbs in half-watt lamps enabled smaller reflectors to be used. This is so to a degree, but it must not be carried too far, as it has to be remembered that the intrinsic brilliancy might be undesirably high, and he thought with the half-watt lamp this factor would have quite an important influence on the size of the unit. The very high value (upwards of 5000 c.p. per square inch) for this intrinsic brilliancy showed how very necessary it was to use suitable reflectors with lamps of this kind.

Mr. Leon Gaster said that the greater range of candlepower and varied distribution of light from incandescent lamps afforded new opportunities to the illuminating engineer, and made it important that their illuminating power should be accurately specified. At a discussion on this subject at the meeting held in March, 1915, the view had been expressed that the mean spherical candlepower should also be stated. This view was being taken up by leading Continental lampmakers. For example, he noticed that a two-page announcement, now being issued with regard to a new type of small candlepower gas-filled lamp laid stress on the uncertainties caused by existing methods of stating candlepower, and announced the intention of stating, beside the watts, also the mean spherical candlepower in future. On the second page of the announcement the following particulars, among others, were given :—

Voltage.	Watts.	Mean spherical C.P. (approx. H.K.)	C.P. in an axial direction (approx. H.K.)
100—130	40	45	55
	60	70	85
	75	90	110
	100	130	160
200—250	75	80	100
	100	110	140

This is in accordance with the practice largely adopted in Germany to mark the voltage and watts on the lamp, and to give in the literature also the approximate mean spherical and the horizontal candlepower.

The invention of the gas-filled lamp was doubtless an important step forward, and it was interesting to observe the transition from lamps of high candlepower and low voltage to low candlepower and high voltage, just as took place in the case of the ordinary tungsten lamp. He hoped, however, that manufacturers would exercise restraint in this matter, and not unduly push forward with the low candlepower high voltage units until an adequate life was obtainable. In his experience the life of these units was less satisfactory than that of the larger types ; in cases where a very low rate for electricity could be obtained there was little advantage in using half-watt lamps unless a life of at least 600 hours was attained, otherwise the cost of maintenance might be too high to enable any economy to be made. It must also be remembered that when comparatively large lighting units are employed the sudden extinction of a lamp illuminating a large section of a room was often highly inconvenient, especially where delicate manufacturing operations were in progress.

The question had been raised whether lamps with specially designed filaments intended to give different light distribution should not be more widely used. He was inclined to think that a better solution of the problem was to rely on the variety of reflectors now available for the purpose of modifying the distribution of light according to the local circumstances, and to aim at the production of a standard type of lamp, which could be gradually perfected and cheapened by manufacturers.

The recent development in lamps also made it necessary for the public to receive guidance. It was essential for lampmakers and manufacturers of reflectors to work together, so that the lamp and its appropriate reflectors became regarded as "one unit," and both were used to the best advantage.

In this connection it might be remarked, as a matter of history, that to his knowledge the Holophane Co. was the first in this country to establish an illuminating engineering department, and to publish in their catalogues distribution curves of the various types of reflectors made by them, and to give advice regarding their use. During the last few years several of the leading companies have developed illuminating engineering departments, and are doing good work in helping the public to obtain scientific illumination. Progress in this respect was in a great measure due to the development of the movement in this country, which had been steadily educating the public to appreciate the claims of good illumination, and to recognise the need for discrimination in the selection of illuminants and the proper appliances for use with them.

As an instance of the recent advance in lighting values it was interesting to quote some figures given by Mr. P. S. Millar before the Illuminating Engineering Society in the United States in 1913 :—

Year.	Approx. average C.P. of all incandescent lamps sold.
1906	18
1907	19
1908	21
1909	23
1910	25
1911	26
1912	29
1913 (estd.)	32

These figures showed very clearly that the standard of illumination during the period 1906-13 had almost doubled, and it was interesting to observe that the illuminating engineering movement in the States was initiated in 1906, and had since largely influenced the progress of lighting in that country.

There was no doubt that meetings of the Society, by making clearer the requirements in connection with various problems in illumination (such as the lighting of schools, libraries, and factories and workshops of various kinds), and by bringing about general agreement as to the chief qualities desirable in globes, shades, and reflectors, had given a great stimulus to the efforts of manufacturers and had brought about a more discerning attitude on the part of the general public. Many of the improvements of recent years were to be traced to the discussions at meetings of the Society.

He observed that within the last few months companies had taken advantage of the issue of the Home Office Departmental Committee's Report on Factory Lighting to offer the services of their illuminating engineering departments to the public in planning lighting installations in factories. But it must be agreed that those who wished to assist the public should themselves be kept fully informed of the latest advances in the subject, and in this respect the platform of the Illuminating Engineering Society in this country was undoubtedly of great value to those concerned with illumination.

Finally, Mr. Gaster said that he wished to associate himself with other speakers in congratulating Mr. Gimingham and Mr. Mullard on the new lamp shown that night for the first time, which appeared to have some interesting possible applications.

Mr. J. S. Dow (*communicated*) : I was much interested in the new lamp described by Mr. Mullard. Some time ago I made some experiments in conjunction with Mr. Mackinney, on a suggested form of projection arrangement for small lanterns in which the condenser was replaced by an elliptical mirror. It was hoped by this means to improve on the enormous inefficiency of the ordinary method of projection. A small incandescent lamp was placed at one focus of the mirror, the idea being that every ray reflected from the mirror should be collected on the objective lens, which was placed at the other focus, the lantern slide being situated between the foci. The arrangement did not answer for the existing form of filament chiefly because this did not approach sufficiently near to a point, with the result that the rays were not satisfactorily concentrated at the second focus and no great gain in efficiency was secured. But with such an incandescent source as that shown by Mr. Mullard the principle might be worth a second trial.

With regard to the figure for the intrinsic brilliancy of the half-watt lamp it is somewhat of a surprise to find this so high. The ratio between the intrinsic brilliancies of the ordinary tungsten and the carbon filament lamp is about the same as the ratio between their efficiencies. Seeing that the efficiency of the half-watt lamp is stated to be about twice that of the ordinary tungsten filament, one would have anticipated an intrinsic brilliancy of about 2,000 candles per square inch. Even if there is a certain loss by convection and conduction of heat owing to the gaseous atmosphere round the filament it seems rather difficult to account for this seeming discrepancy.

The CHAIRMAN, in winding up the discussion, said that the first slide which had been put upon the screen by Professor Morris gave an exceedingly interesting historical review, but it did not state what he believed was the absolute truth, namely, that nearly all progress with electric lamps was due to the indisputable circumstance that electricity had to compete with gas. The discoveries in connection with each system of lighting had given a stimulus to the other. It was the discovery of the principle of the incandescent mantle by Auer von Welsbach, in Austria, a generation ago, which improved gas lighting to such an extent that electric lighting was bound to follow suit or be displaced.

The historical table began with the lamp associated with the names of Edison and Swan. This, however, should be Swan and Edison, for did not Swan show an incandescent carbon lamp at work at a lecture given in Newcastle on December 18th, 1878, before any other had been shown? And was it not shown subsequently in the very room in which this meeting was being held, where also so many new things had been shown for the first time in London, many years ago? Indeed, that particular lamp was on view this evening.

Many years after the carbon lamp had been improved, Nernst brought out that stick of glorified pipe-clay, which he made into the Nernst filament. In that he was indebted unquestionably to Auer von Welsbach, because Auer used in his mantles, but in different proportions, the very same rare earth which were afterwards applied by Nernst in his filaments.

Then came the next invention in electric lighting, namely, the Osmium lamp, utilising a very rare metal again introduced by Auer von Welsbach, a metal whose rarity soon compelled inventors to seek for other materials. This no doubt led to the suggestion that tantalum should be used, although it was not originally so good as osmium; and afterwards came the tungsten lamp. A few years ago much was heard of other materials, such as those introduced into the zirconium lamp, but little was heard of this material to-day. He did not see, however, why molybdenum, or an alloy of this metal with tungsten, which is closely resembled, should not be used. It was quite possible that there were other metals which had not yet been fully exploited, and might be utilised in the near future.

The original Swan lamps were sold at a guinea apiece; they eventually came down to somewhere in the neighbourhood of 5½d. or 6d. That was a good long drop, and he was wondering when the tungsten lamp would fall to anything like that figure. At present he had to pay 2s. 2d. for a tungsten lamp, which could not possibly cost nearly as much as that to manufacture, and he was looking forward to the time when the cost to the user would be something like 8d. or 9d. A little competition would perhaps hasten this result. The cost of the half-watt lamps was in the neighbourhood of £1; but here again he hoped that the time was not far distant when the price would fall to a value that could more readily be paid by the humble citizen. What the cost of the newest lamp Mr. Mullard had shown he supposed was not known as yet.

Those present had heard incidentally of problems in connection with the photometry of some of these specially shaped filaments, and the question had been raised as to whether the candlepower should be expressed in terms of the horizontal, mean lower hemi-spherical, or mean spherical value. No one, so far as he recalled, had suggested that the exceedingly simple method of obtaining the mean spherical candlepower through the agency of the Ulbricht Globe, or some similar chamber with white walls, which could be used for the purpose.

Returning to the lamp shown by Mr. Mullard, he was much struck by the novelty of the principle employed, which was exceedingly interesting from a scientific point of view; he felt confident that the research would not be allowed to remain as a laboratory experiment, but would be carried to a commercial stage. Was it not possible that they had that evening witnessed a historical event? Those gentlemen who were present at the lecture delivered by the late Sir Joseph Swan at Newcastle in 1878, must have felt afterwards that they had witnessed the actual making of history. Possibly those now present would have a similar experience.

In conclusion, he had much pleasure in proposing a hearty vote of thanks to Professor Morris for his exceedingly interesting introduction to the discussion; to Mr. Mullard for having enabled the meeting to see this new lamp, now for the first time shown in public; and to Mr. Willcox for the very helpful observations he had made, especially in regard to the far-reaching and revolutionary changes being brought about by the half-watt lamp.

Professor J. T. MORRIS (in reply):—I am quite in agreement with Mr. Willcox as to the importance of the exact position of the shade with regard to the lamp; it was in fact a point to which I had directed attention in the short synopsis circulated before the meeting. I was glad to learn from him that some manufacturers are giving this matter especial attention. With regard, however, to the ideal distribution of light from a lamp, surely this is better done, as far as possible in the first instance, by a proper disposition of the filament, for it is obvious that whenever light has to be redirected by a shade or reflector some must inevitably be lost.

Mr. Willcox made much of the half-watt lamp and a new series of reflectors designed for use with it. One cannot but admire the skill which has been brought to bear in the design and production of these reflectors. We must not, however, forget—as Mr. Gaster, Mr. Cunnington, and others pointed out—that unless experience shows that a reasonable length of life can be expected from half-watt lamps the result in the long run will be far from proving a commercial success, owing to the high cost of lamp renewals.

Mr. Willcox seemed sceptical as to my results obtained by the change from straight filament to spiral filament tungsten lamps of the vacuum type. I can only assure him that these results have been obtained under commercial conditions over a period of nearly two years, and relate to some two or three hundred points.

I was much interested in Mr. Cooper's arrangement for lighting a chemical balance, which certainly possesses the advantage of flexibility. It is, however, open to the objection that it is a special device, whereas in my arrangement both lamp and bracket are stock articles and simply laid on the top of the balance; the lamp used also has a metal filament, and therefore for the same candlepower does not give out so much heat. There is also the further objection that in the case of my balance Mr. Cooper's arrangement would be inapplicable owing to obstruction from the woodwork on the top of the balance.

In reply to Mr. Cunnington's question, the results for the half-watt lamp (1,490 watts), given in Table II., are based on the horizontal candlepower, and yield an efficiency of 0·58 w/cp.

Mr. Cunnington suggested that it might be economical to under run half-watt lamps; and in this I am inclined to agree with him, and especially in the case of the higher voltage low candlepower lamps.

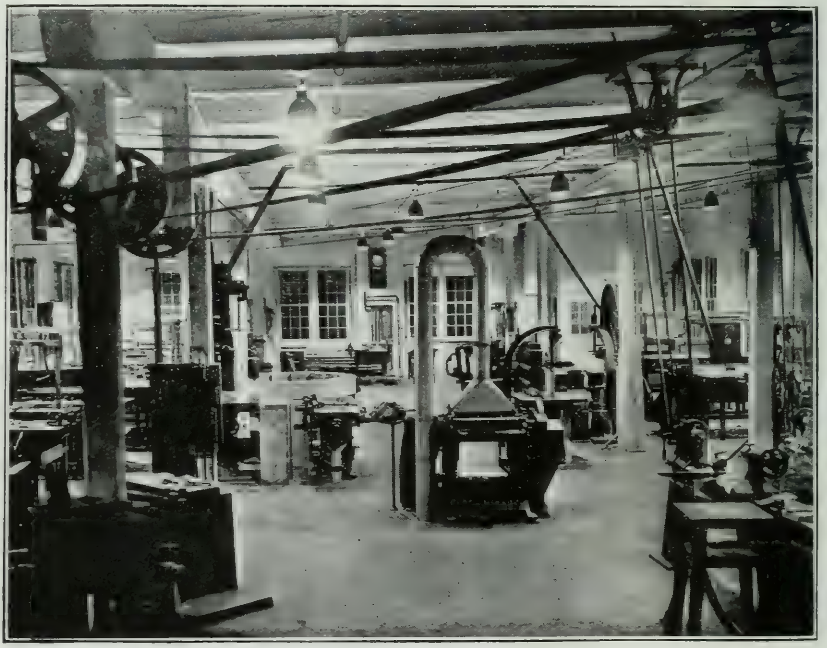
The experience which I have had tends to confirm Mr. Stroud's opinion that the alteration in the polar curve of light distribution in changing to the spiral tungsten (excluding the half-watt) lamp, though inappreciable, is not serious if the lamps are sufficiently closely spaced.

On the whole, the views expressed by the various contributors to the discussion have confirmed me in the belief that tungsten lamps of the vacuum type, which mainly send their rays downwards should be more widely used in cases, of which there are many, in which a horizontal surface has to be lighted. Also with regard to half-watt lamps, though these are satisfactory when in large sizes and used with suitable fittings, they should be used in the smaller sizes with caution until greater reliability in their performance is obtainable.

In view of Dr. Silvanus Thompson's remarks I have added some particulars of Osmium lamps to the tables so as to render them more complete. I should like also to express my appreciation of his kindness in presiding on this occasion.

OVERHEAD SHOP LIGHTING.

THE illustration below was sent us some time ago by Mr. J. L. Stair, of the National X-Ray Co., of Chicago. It illustrates the value of lighting shops on the overhead system, so that, in spite of the presence of a considerable amount of belting, the space is left clear, and the distribution of a strong general illumination enables all the details of the machinery to be clearly seem. In this case the effect of the opaque reflectors on the ceiling is evidently assisted by the white walls.



The room is 116 ft. long, 50 ft. wide and 13 ft. high and is lighted by 40 100-watt lamps in Bee Hive reflectors spaced 10 ft. apart and 9 ft. above benches. Formerly the room was lighted by a combination of arc lamps and local lights, each bench having three small 16 c.p. lamps.

Now the ceiling lighting does everything that is required and there is said to be a considerable saving of time owing to the fact that the workman is no longer obliged to adjust his lamps to every new position he assumes, as was formerly the case.

While ceiling lighting on this principle is conducive to a good general illumination, it is also applicable in cases of "localised general" lighting when it is desired to concentrate more light at some points than others owing to the presence of particular machinery; the desired accentuation of illumination at certain points is readily accomplished by using a higher candlepower lamp at that spot.

SHORT NOTES ON ILLUMINATING ENGINEERING.

WAR LIGHTING.

(From a recent issue of *The Gas World.*)

STREET lighting in Glasgow is to be reduced to not more than 60 per cent. of what it is at normal times, in accordance with an order issued by the military authorities. The order also applies to shop-front lighting, &c.

Complaints of insufficient street lighting were made at a meeting of the Huddersfield Town Council on the 20th inst. Mr. R. Mitchell, Chairman of the Gas Committee, in reply, said that it had been decided that every other lamp should be lighted and those at street corners wherever possible. He thought, however, if economy was intended, it was false economy. If it were a precaution against air raids, it was futile. The only way to provide against air raids was to extinguish all the lamps. The Mayor said the saving of coal was a great consideration, and the Council had no business to waste anything at present.

The Car-luke sub-committee of the Upper Ward District Committee of the Lanark County Council have refused to take the advice of the Committee and reduce the public lighting for the sake of economy.

Liverpool is at present lighted by the following lamps :— Incandescent gas, 12,513 ; flat-flame, 2,677 ; electric, 551 ; and oil, 93. This shows a large reduction, due to the decision of the Lighting Committee to fall in with the suggestion of the Government to curtail the street lighting with a view of effecting economies. The number of gas lamps not lighted are :—Old city, 4,329 ; surburban areas, 2,879 ; total, 7,208. The whole of the electric arc lighting has been discontinued at the request of the Mersey defence authority. The number of electric lamps has fallen from 1,129 last year to 551.

In Macclesfield, as in so many other towns, there are complaints about the want of light in the streets. There was a discussion on this matter (without any result) at the last meeting of the Council. A member expressed the opinion of many others in saying that they were certainly not carrying out anything that would prevent a raid, and were causing themselves a lot of inconvenience and trouble. Another declared that if the restriction was carried out for the purpose of saving expense, then it was a foolish saving.

ERRATA.

We observe that through a clerical error the name of Mr. W. F. Little (who co-operated with Dr. Clayton H. Sharp in a paper on a Compensated Test Plate for Illumination Photometers read at the recent Convention) was incorrectly given as " Mr. T. J. Litle " on p. 444 in the *Illuminating Engineer* for November 1915.

With reference to the note on a Series of Lectures on Illuminating Engineering on p. 457 in the same issue, we now understand that the University of Philadelphia has invited the American Illuminating Engineering Society to hold the course of lectures at that institution.

SEARCHLIGHTS FOR THE ILLUMINATION OF BATHING PLACES

For several years the authorities in Chicago have been trying to promote the use of the 22 miles of frontage on Lake Michigan for recreation, and it is largely used in the season for bathing.

There are, however, many people in Chicago who can only get free from their business at night time—in fact, fully 90 per cent. of the patrons of these bathing places are engaged until after 5 o'clock or later, so that they can only make use of the beaches about dusk. Several accidents have occurred which could probably have been prevented in the day-time. Moreover, there has been a tendency for the rowdy element in the population to behave in a disorderly manner under cover of darkness.

According to the *Electrical Review and Western Electrician*, experiments are now being made with artificial illumination, so that the beach can be used with the same facility as in the day. At present it has been found practicable to illuminate sections of the beach with projection arc lamps, whose position was so selected that sands and water are flooded with a soft light and there is practically no glare. It is believed that this method will be used regularly on the beaches next summer. It is possible, however, that gas filled incandescent lamps will be substituted for the arcs.

NIGHT ILLUMINATION OF A SWIMMING POOL.

The Delmar Swimming Pool at St. Louis has recently been illuminated artificially by electric light and the installation was described in the *Electrical World*. Five hundred watt lamps (tungsten) are suspended on cables hung across the pool. This pool is very popular during the summer and the new lamps have been receiving a great deal of attention. Swimming during the night time is becoming quite a popular pastime.

STANDARDISING POCKET LAMPS.

We note that the *Elektrotechnische Zeitschrift* for May 27th contains an article discussing the standardisation of small pocket lamps. The figures given for the life of such appliances, which depend on the capacity of the battery, are often very vague.

In order to define this more precisely it is suggested that the life of a pocket battery should be defined as the time during which a discharge of 0·2 amp. through the lamp reduces the voltage of the battery from 4·5 to 1·8. After this the battery must be renewed though in an emergency it might be possible to carry the discharge down to 1·5 volts. If the lamp is only used intermittently, for short flashes, the life would probably be 50 per cent. greater.

INVISIBLE SANDBAGS.

On other occasions we have mentioned instances of the important rôle played by the visibility of distant objects in the present war. For example, the question of designing uniforms of soldiers so as to be as inconspicuous as possible has been discussed, and it is well known that ships and forts are painted in a special manner in order to render them indistinguishable at a distance.

Another interesting example was quoted in a recent issue of the *Times*. An officer at the Front draws attention to the way the sandbags were arranged in the German trenches. It appears that the Germans have adopted the device of using a few dark coloured sandbags at intervals among the lighter ones, so as to produce a sort of patchwork. As a result it is quite difficult to determine their loopholes. A man may fire away at a supposed loophole for hours, only to discover that he has been wasting ammunition on a sandbag.

It has also been suggested that the explanation of these variegated colours lies in the fact that the Germans are short of the materials ordinarily used for making sandbags. However this may be, it would appear from the above experience that the use of this patchwork device is a happy one, and might lead to the saving of a great many lives in the course of a campaign.

THE DEVELOPMENT OF ELECTRIC INCANDESCENT LAMPS FROM 1908 TO 1914.

A RECENT article by X. Remy in the *Bulletin* of the *Association Suisse des Electriciens* (No. 12, December 1915), contains some notes on the testing and rating of electric incandescent lamps. Of special interest is the diagram, reproduced herewith, showing the life of lamps, as determined at the Testing Station of the Association Suisse des Electriciens, and published at the Exhibition in Berne in 1914.

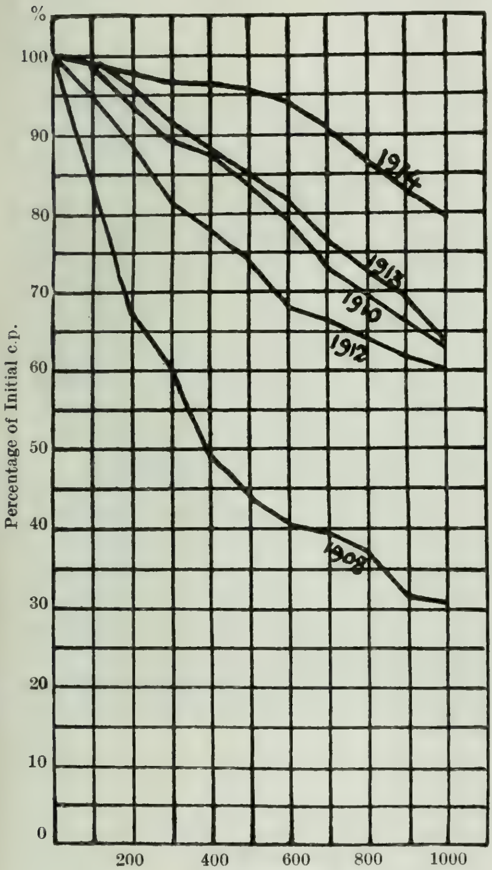


FIG. 1.—Comparison of life of metal filament lamps during the years 1908—1914.

Considerable progress was made from 1908 to 1910, but until 1913 no further great advance was made. After this year, however, the introduction of drawn tungsten wire in place of squirted filaments led to a distinct improvement, as shown by the 1914 curve. It is stated that 80 per cent. of the present lamps attain a life of not less than 1,000 hours.

The author also discusses the development of special forms of lamps, concentrating the light in particular directions. He gives a series of diagrams illustrating the variation met with in distribution of light. On the whole, he thinks that the development of special filaments of this kind is hardly worth while, seeing that in any case they must be used with appropriate reflectors. Consequently it seems unnecessary to shape the filaments with a view to producing special polar curves of light-distribution, and it seems better to adopt a uniform type of filament and to rely on the reflectors to produce any particular direction of light that may be needed in practice. The adoption of a standard form of filament enables makers to concentrate on this model, and thus to bring it to a greater stage of uniformity and perfection.

However, seeing that such variations exist, and that further diversity in distribution of light is introduced in the new "half-watt" lamps, it seems that the most reliable method of specifying their illuminating value is to give the mean spherical candlepower. The testing of this value is less simple than the determination of horizontal candlepower, but the factor connecting these two quantities varies within small limits for the same type of lamp, and may therefore be used as a basis of testing. On the other hand, if special forms of filaments are considered variations in the factor, from 0·82 to 1·11 may be encountered. For determining mean spherical candlepower the Ulbricht globe also deserves to be more widely used.

Turning to the rating and marking of lamps, the author summarises the discussions on this subject that have appeared before the Illuminating Engineering Society in this country,* and the Institution of Electrical Engineers† in Germany. There is a tendency among makers (in Germany, for example), to inscribe only the watts and pressure on the lamps, but to state also the candlepower in literature relating thereto. On the other hand, the public understands the meaning of candlepower better than the wattage, and the use of the former term has therefore commended itself to central stations who, as the largest purchasers, have naturally a considerable influence in determining the procedure in this respect. In Switzerland most central stations continue to have lamps marked in candlepower. The author suggests that eventually both candlepower and watts may be indicated on the lamp. Meantime the method, largely favoured in England, of rating and standardising the lamps in watts, but marking the approximate candlepower on the bulb, deserves consideration.

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* ILLUM. ENG. No. 4, Vol. VIII., April, 1915.

† *Elektrotechnische Zeitschrift*, 1915, p. 216.

SUPPLY COMPANIES SHOULD TEACH GOOD LIGHTING.

The central station as a public servant should teach the principles of good lighting. Without resorting to technical language it is a simple matter to explain this efficiency of illumination to consumers. Let them understand how essential artificial light is to modern life. Show them that the electric bill is not a war tax to which they must subscribe whether they like to or not, but rather it is a small sum for which they get something that lengthens the day and gives additional hours for labour or recreation. Explain the harm of glare, flickering, shadows, over-lighting and under-lighting—in short, the essentials of good illumination.

Only in this way can we approach the desired Utopia—a host of satisfied customers.—R. E. Smith, *Jour. of Elec. Power and Gas,* Nov. 13th.

ILLUMINATED NAME-SIGNS ON NEUTRAL VESSELS.

One result of the menace to neutral vessels owing to submarine warfare has been the adoption of illuminated name-signs which are visible afar off. It is stated that the Holland-America line has decided to paint the name of the vessel on the ship in large letters, and also a statement whether it is a cargo or passenger boat. In addition, boards bearing the name of the ship and its port are to be erected on deck and will be illuminated by night. Some companies are also painting their ships in the national colours.

LETTING THE PEOPLE KNOW ABOUT THEIR STREET LIGHTING.

Display lighting of the so-called " white-way " type would seem to require little external publicity, but on the recent inauguration of a system of this kind at Lowell, Mass., the local central station made effective use of the city dailies to tell the public some of the essential points bearing upon the new work.

Thus, in one advertisement, covering an entire page, the company pointed out that local labour was employed throughout in the construction of the system. The dates of beginning and ending work under the contract with the city were given, with some particulars as to the selection of lamps and poles and the amount of cable, conduit and new power-station equipment needed. A signed letter from Mr. Edison to the Mayor of the City, congratulating the latter upon the installation, was exhibited in the lighting company's office window.—*Elec. World*, Nov. 13th, 1915.

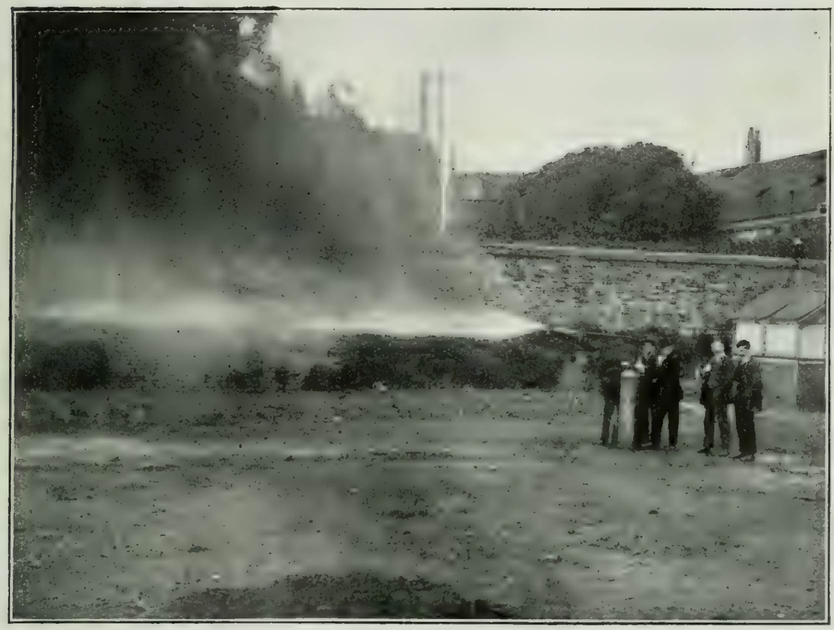
MUSIC FROM LIGHT.

In the *Electrical Review and Western Electrician* (Nov. 13th) a novel development of the " Oscillating Audion " use in the de Forest System of radio telephony is described. The audion of a special form of electric incandescent lamp, into which a grid-shaped wire and a nickel plate are sealed, in addition to the ordinary filament. The lamp acts as a detector of wireless waves, but, if certain conditions are complied with in the electric circuit it produces an alternating current, which, acting on the diaphragm of a telephone, emits a musical note of surprising sweetness of tone. By using a keyboard controlling the electric circuit a complete octave can be obtained from one lamp, and successive octaves can be produced from others. Thus, by using a series of lamps, common to one set of telephone receivers, regular orchestral effects can be produced.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]



THE KITSON FLAME PROJECTOR.

Readers will be familiar with the system of incandescent oil lighting supplied by the Kitson Empire Lighting Co., Ltd. The company has now designed, for military purposes, a special flame projector, which is illustrated in the above photograph.

The fuel consists of a special mixture of hydrocarbons, operated at a pressure of 200 lb. to the square inch; the burner is heated with methylated spirit in order to start the flame which is projected a distance of 60—70 yards. It is said that the heat is so intense that no one could approach close to the projector without getting severely scorched. According to *Engineering*, it is hoped to increase this distance to 100 yards.

We are informed that portable projectors capable of being strapped to a man's back are also constructed.

A NEW FORM OF LAMP FOR LANTERN AND PROJECTION WORK.

The two illustrations on the opposite page refer to a very interesting new form of lamp for projection purposes which has just been brought out by the **Edison and Swan United Electric Light Co., Ltd.**

The "Pointolite" lamp is in reality an arc within a sealed bulb. It can, however, be treated just like an incandescent lamp and, after being switched on, requires no manipulation. By the aid of a special subsidiary ionising filament an arc is struck on a small globule of tungsten which becomes incandescent all over, thus furnishing a very suitable form of source for projection purposes; it is, in fact, a "point of light," and thus differs from an ordinary incandescent lamp, consisting of a coiled filament, which is apt to give rise to striations when applied to lantern work, and is not sufficiently concentrated to give a really satisfactory image.

In the illustration a suitable form of resistance for use with the arc is shown, together with switch and special three-point holder. The whole is very compact, and is easily applied to an ordinary lantern. The type of lamp used is stated to give about 100 candles and to operate at 0·65 watts per candle.

It will be interesting to see what applications this new lamp has for cinematograph work, for which we understand special lamps (presumably of higher candlepower) will be available shortly. It is also expected that the lamp will have useful applications for searchlights.

Demonstrations of the lamp are being given at the Company's showrooms (123—125, Victoria Street, S.W.).

FIRE AT THE EDISWAN WORKS, PONDERS END.

On Saturday, December 11th, a fire broke out in the Joiners' Shop at the Ediswan Works at Ponders End. We are informed that the fire did not spread, and was fortunately confined entirely to this department. The self-contained nature of the works enabled things to be readily set going again on the Monday morning, when work was resumed.

CONTRACTS RECEIVED.

We are informed that the tender of Messrs. **Siemens Bros. Dynamo Works, Ltd.**, for the supply of Wotan, Tantalum and Carbon lamps to the Aberdeen Line for the year 1916, and also a tender to the Royal Mail Steam Packet Co., for the same period, have been accepted.

OSRAM LAMPS.—**The General Electric Co., Ltd.,** advises us that for the seventh time it has received the G.P.O. (six monthly) contract for the supply of Osram drawn-wire lamps.

The G.E.C. has also received contracts for the supply of many thousands of Osram and Robertson lamps to the Admiralty and War Office.

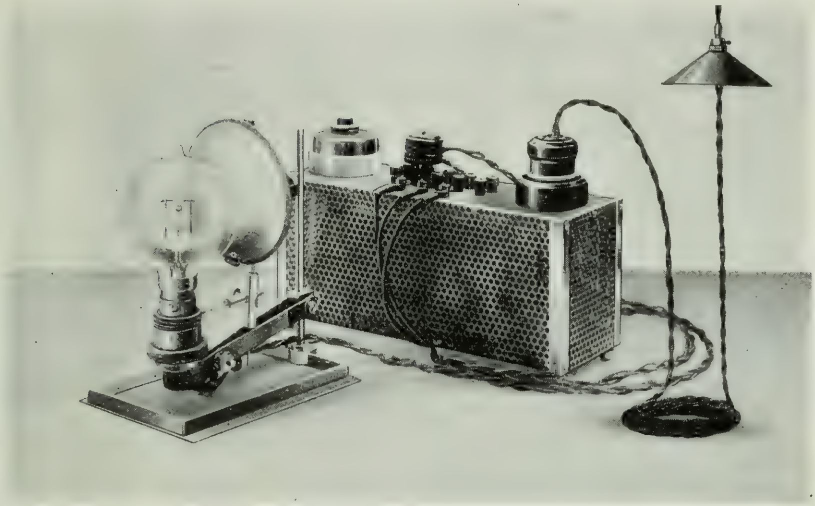


FIG. 1.—Showing "Pointolite" lamp fitted with reflector ready for insertion in lantern, together with resistance box and connections.

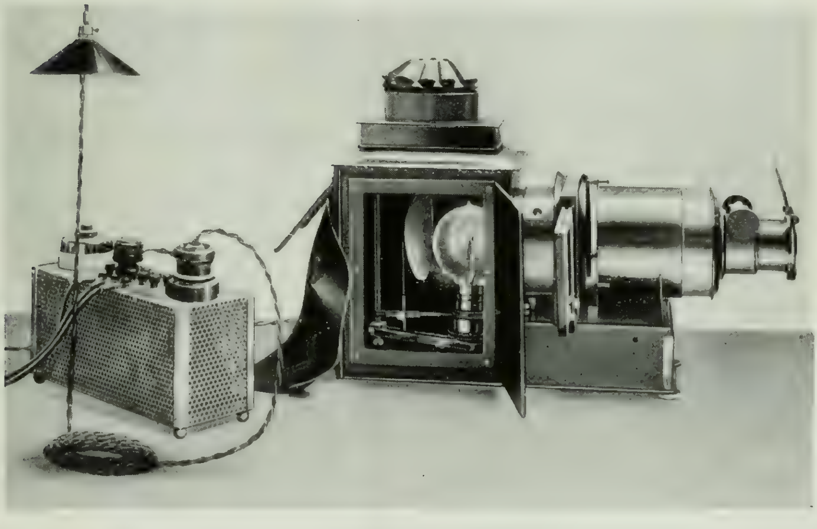


FIG. 2.—Shows "Pointolite" lamp inside lantern ready for use.

REVIEWS OF BOOKS.

"*A Treatise on Light.*" *By R. A. Houston, M.A., Ph.D., D.Sc.* (*Longmans, Green & Co., London,* 1915; 478 *pages,* 328 *illustrations.*)

PROFESSOR HOUSTON deals with his subject exceptionally fully, and it is evident that this branch of study is attracting considerable attention just now. The first portion of the book (Part 1) deals with systems of mirrors and lenses, optical instruments, &c. In Parts 2 and 3 Physical Optics and Spectroscopy receive exceptionally detailed treatment. A section of the book which many people will find particularly interesting is that dealing with recent work in Spectroscopy and the infra-red and X-rays. The use of Echelon grating is described, and there is an excellent diagram showing the range of vibrations throughout the entire spectrum. The chapters on Photometry and Lamps and Illumination are extremely brief, and an expert would probably find several points that deserve modification. We notice, for example, that the so-called "international unit of light" is not mentioned, and among incandescent lamps the "half-watt" lamp is omitted. We are glad to see, in the chapter on the Eye and Colour Vision, a somewhat fuller account of the physiological side of the subject than usually appears in textbooks on optics. The final portion of the book is devoted to a mathematical discussion on the nature of light and radiation. At the end of each chapter there is a series of examples. The book should be of considerable interest to advanced students in optics.

"*Electrical Engineers' Diary for* 1916." (*S. Davis & Co., London.*)

THE Electrical Engineers' Diary once more makes its appearance. Besides the familiar data on engineering matters this issue contains one entirely new feature, namely, a special section on Industrial Lighting, occupying 24 pages. The section commences with a summary of the First Report of the Departmental Committee on the Lighting of Factories and Workshops. This is followed by a series of notes on factory lighting, illustrated by photographs and data relating to various actual installations. Such matters as the avoidance of glare and inconvenient shadows, the choice of general or local illumination, direct or indirect lighting, &c., are discussed, and some simple rules for calculations of illuminating engineering given. There are also some special notes on the lighting of machine shops and clothing factories, &c. The section is concluded by a concise specification summarising the chief lighting requirements of a number of different trades. This section is particularly appropriate at the present time, when so many factories are working overtime on Government contracts, and we hope that it will form a permanent feature of the Diary.

PERSONAL.

WE note that Mr. R. H. Palmer, late advertising manager of the Welsbach Light Co., Ltd., has accepted a commission in the R.N. Motor Boat Patrol Section.

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The Kitson Flame Projector—New Form of Incandescent Lamp for Projection Purposes—Contracts Received—An Attractive Gas-Lighted Show Window.

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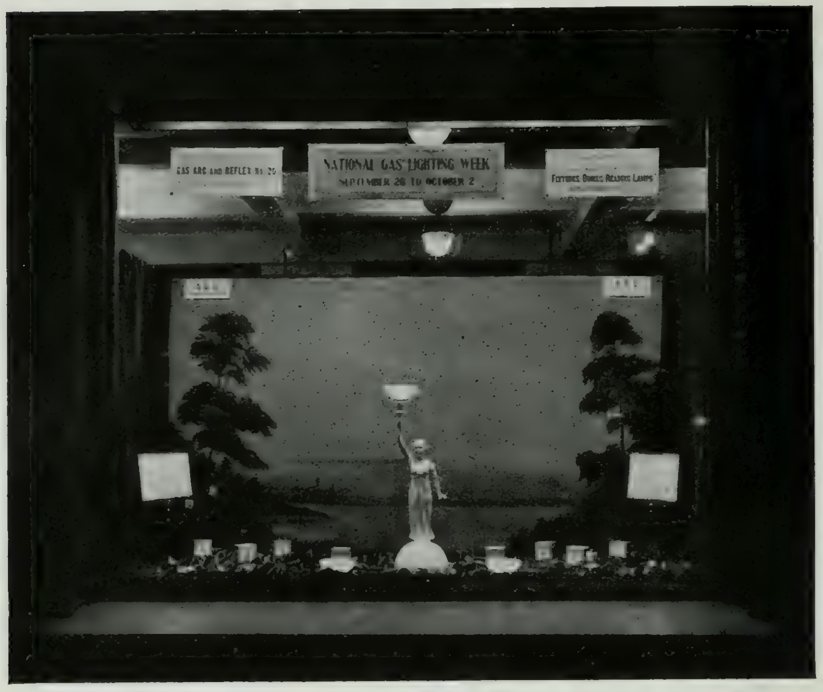
AN ATTRACTIVE GAS-LIGHTED SHOW WINDOW.


GAS ARC AND REFLEX No 20
NATIONAL GAS LIGHTING WEEK
SEPTEMBER 26 TO OCTOBER 2
FIXTURES BOWLS READING LAMPS

The above illustration depicts one of a series of attractively gas-lighted show windows, arranged during the recent special "Lighting Week" at Jersey City (U.S.A.).

For the photograph from which this block was made we are indebted to the courtesy of the *American Gaslight Journal,* a recent issue of which contains a number of striking illustrations of show windows.

The charm of the display lies mainly in its simplicity. The best judges now recognise that crowding of windows is almost invariably fatal to an artistic display; according to modern ideas a window should be a striking indication of the objects of the shop rather than an attempt to catalogue its entire contents. The main thing is to produce an effect which inevitably attracts and holds the passer-by.

From the lighting standpoint an agreeable feature is the soft effect produced and the absence of glare. It will be seen that the figure holds a bowl of the semi-indirect type; in this display artistic semi-indirect fittings for gas were much in evidence.

Another type of semi-indirect lighting unit which seems to be at present finding favour in the United States, utilises four bowls supported on straight arms. Not only is the subdivision of the units—and the resulting improved diffusion of light—beneficial, but the fact that the heat is less concentrated is also an advantage. There are four upward currents of air instead of one, and there is therefore less tendency to discolouration of ceilings.

The
ILLUMINATING
ENGINEER

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

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Illuminating Engineering Society.
(Founded in London, 1909.)

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EDITORIAL.

Data on Industrial Lighting.

The discussion on Industrial Lighting, opened by Mr. Dow at the last meeting of the Illuminating Engineering Society on January 10th, formed a useful addition to the discussion on the Home Office Report on Factory Lighting, opened by the writer last November. The meeting in November dealt with the general aspects of the Report and the recommendations made therein; the discussion opened by Mr. Dow made special reference to the recently issued Vol. III. of the Report, containing the account of observations in factories and workshops.

We commend this volume to the careful attention of lighting engineers. On pages 44 and 45 we reproduce, by kind permission of the Controller of His Majesty's Stationery Office, two typical sheets of observations and diagrams. Side by side with the actual measurements in each factory the personal impressions of the Committee are recorded, so that altogether the volume contains a unique amount of information regarding the existing conditions in the classes of factories visited. Such a complete series of statistics has never, we believe, been published before in this or any other country. It affords positive information on many facts which would otherwise have been a matter of conjecture; showing, for example, that the suggested minimum illumination of 0·25 foot-candles in the interests of safety is exceeded in about two-thirds of the factories visited, and can therefore be reasonably demanded.

It need not be said, however, that in many cases manufacturers would, for their own sakes, prefer an illumination well above the absolute minimum, and a glance over the contents of Vol. III. shows that in many cases out-of-date lamps and lighting appliances are still in use, and that by installing more modern methods of lighting considerable improvements could easily be made. Such data are thus of great interest to lighting engineers, as indicating the trades in which there are opportunities for improvement.

The chief object in the discussion introduced by Mr. Dow, apart from the account given of Vol. III., was to show by practical examples of actual gas and electric installations, that the requirements of the Report can be readily met by the aid of modern methods. Particulars of such installations were kindly furnished by various members of the Society, and were impartially presented and described by Mr. Dow. The subsequent discussion fully bore out the view that the resources of illuminating engineering are quite able to cope with what is demanded, and that there is nothing excessive in the recommendations of the Committee.

The requirements as regards absence of glare, reasonable uniformity of illumination, and avoidance of inconvenient shadows are entirely in accordance with the views expressed at previous meetings of the Society. There are doubtless special cases in which difficulties must be overcome, where, for example, it is rather a problem how to get the desired shadow conditions without unduly exposing the sources of light. In such cases, it was pointed out, the diffusion of the light by reflection from walls, ceilings, and even floors is a most important item. Objects in general can only be seen completely when illuminated by light coming from many different directions, and it is the absence of the reflected light which makes the most fundamental difference between interior and exterior lighting. Diffusion from light surroundings, in short, is one of the most important features in good factory lighting.

Assuming that the requirements of the Committee are readily met, there arises a second question, how far it is practicable to determine beforehand what the illumination resulting from any arrangement of lamps and reflectors will be? The answer to this question was given by the paper by Mr. W. C. Clinton before the Society in 1914, which showed how, by taking sufficient care, the illumination could be calculated with considerable exactitude. Mr. Dow's introductory remarks also showed that, even without the refinements in calculation necessary for exact predictions, the approximate illumination can be readily calculated, provided that types of lamps and reflectors are used for which the polar curves of light distribution are accurately known. During recent years manufacturers of lighting appliances have done much to facilitate such pre-determinations, and the development of convenient instruments for measuring illumination has provided a means of verifying them and given lighting engineers confidence in the results of their calculations.

In the discussion there was full agreement on this point. It was, however, pointed out that in one section of calculations fuller data are desirable, namely, in estimating the effect of reflection from surroundings. Those who have had practical experience of various types of lighting installations can frequently make a good judgment on this point, and in any case such reflected light is usually regarded as a "margin in hand," causing the actual illumination to work somewhat *higher* than that anticipated from calculations. It is thus an error on the right side. It would, however, be of interest to examine this question somewhat more closely so as to smooth the path of those who have not had much experience of such problems.

We should, however, like to take this opportunity of expressing our full agreement with the view that a measurement of illumination *alone* is not a sufficient indication of the adequacy of a lighting installation. The opinion is now very generally held that a measurement of horizontal illumination is, on the whole, by far the most convenient method of specifying illumination at any point; it hardly seems desirable to abandon this simplicity and to add requirements as regards vertical illumination. Yet it is of course agreed that in many cases good illumination of vertical surfaces is also necessary. But this requirement might be met by laying stress on the need for good diffusion of light in such cases. If, by subdividing the lighting into small units and by judicious utilisation of reflection from light surroundings, we can secure the requisite uniformity of illumination and avoid inconvenient shadows, we shall at the same time secure the desirable illumination of vertical surfaces. Another reason for advocating good diffusion of light is that severe contrasts in the illumination at different points in a room undoubtedly prejudice the effect of the illumination in the least illuminated spots. We have an excellent illustration of this in the present conditions of lighting in the streets. The effect of passing out of the brilliant illumination immediately under the lamps into the dense obscurity of parts of the pavement remote from the lamps has often been commented upon; such alternations of brightness and darkness are bound to be inconvenient to the eye, and should certainly be avoided in shop-lighting. In order to guard against this the Report wisely requires "a reasonable uniformity of illumination" in addition to the minimum requisite in the interests of safety.

In the discussion the view was also expressed that it may not be necessary to make many subdivisions in classifying the intensity of illumination required for various purposes. There is much to be said for this simplification, and it is possible that, with a few exceptions, this method might answer, provided it were supplemented by suggestions as to the best arrangement and positions of lamps for certain processes so as to ensure that the conditions as regards avoidance of glare and proper direction of light were also complied with. Doubtless certain broad distinctions, similar to those suggested in the American Code, or in the Dutch legislation, might be considered by the Committee.

In conclusion, we should like to repeat what was stated several times in the course of the discussion, that the recommendations in the Report are designed to help the manufacturer, and that it has been expressly framed to avoid any degree of hardship. This being the case, the fact that a certain amount of latitude is allowed, is a distinct advantage. In order to provide for the exercise of toleration it is desirable not to make these requirements too rigid, and to allow a margin for the exercise of human judgment and—we may add—goodwill.

The Marking and Rating of Lamps.

It will be recalled that a discussion on the above subject took place about this time last year.* The problem has arisen in an acute form in connection with the (so-called) half-watt lamps and other incandescent lamps having a special form of filament. This matter is now being discussed on the Continent and in the United States. We observe, for example, that at the last Annual Meeting of the German Illuminating Engineering Society a Report was presented by the Committee on Photometric Methods. There was general agreement that, from a purely physical point of view, the mean spherical candlepower was the most important ; but for practical reasons it was sometimes found inconvenient to depart from the mean horizontal or mean hemispherical candlepower. The Committee therefore recommend, as a tentative step, that besides the above quantities the figures for conversion to the mean spherical candlepower should also be stated.

The difficulty rests very largely in departure from existing usage. We notice that Heyck (Elektrotschnische Zeitschr., Nov. 25th, 1915) approves the rating of incandescent lamps in terms of mean spherical candlepower, but disapproves of the application of this method to arc lamps.

Another Continental article (K. Zickler, Elek. u. Masch., Sept. 26th and Oct. 3rd, 1915) recommends that the watts, volts and mean spherical candlepower should all be indicated on the bulbs of incandescent lamps.

The *Electrical World* in commenting upon these papers agrees that, with the coming of the gas-filled lamps, rating in mean horizontal candlepower has broken down, and that " there can be no doubt that a spherical candlepower basis is technically correct and much superior to a mere mean horizontal candlepower basis." It is pointed out, however, that the change may be considered inexpedient commercially. " An incandescent lamp of, say, 50 candlepower on the old basis might be perhaps only 37 candlepower on the proposed new basis. That is to say, there would be in many cases nothing to indicate the transition from mean horizontal to mean spherical candles."

In an editorial on this subject last year† we suggested a special method of marking, involving the placing of the mean spherical value within a circle and the candlepower in other directions ; for example, the horizontal or maximum values as diverging rays therefrom. The solution approved by the *Electrical World* is to popularise the lumen ; presumably if the output in lumens were stated the discrepancy might pass unnoticed.

It is evident that opinion is veering strongly in favour of a method of rating based on the total light given by the lamp. The question of rating is important in view of the diversity of types of lamps available—particularly so in the case of new types of high voltage and high efficiency, and low wattage. A change in the method of rating would involve fuller education of the public in these matters, and literature relating to lamps should be prepared with this aim in view. We are glad to see that in the latest catalogues, fuller data regarding the performances of lamps, and some suggestions on their selection and use are already being given. This tendency, we believe, is in a large measure due to the educational influence of the illuminating engineering movement in various parts of the world

LEON GASTER.

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* *Illum. Eng.*, April, 1915.

† *Loc. cit.*

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

SOME PRINCIPLES IN INDUSTRIAL LIGHTING.

With special Reference to the First Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops.)

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, London, at 8 p.m., on Tuesday, January 11th, 1916.

A MEETING of the Society took place as stated above, on Tuesday, January 11th, Mr. F. W. Goodenough being in the Chair. The Minutes of the Last Meeting having been taken as read, the Hon. Secretary proceeded to read out the names of applicants for membership in the usual way, and the Chairman then called upon Mr. J. S. Dow to open a discussion on "Some Principles in Industrial Lighting." In doing so Mr. Dow explained that it was hoped, by the aid of numerous examples of actual gas and electric installations, data regarding which had kindly been furnished by various members of the Society, to show how the requirements of the Home Office Committee on Lighting in Factories and Workshops could readily be met by the aid of modern lighting appliances.

An interesting discussion followed in which Mr. H. C. Wheat, Mr. C. C. Paterson, Mr. A. Cunnington, Mr. L. Gaster, Mr. F. W. Willcox, Mr. O. E. Grigsby, Mrs. Cloudesley Brereton, and Mr. C. H. Pitman took part. Mr. Dow intimated his intention of replying to the discussion in the printed account of the proceedings.

In conclusion the Chairman announced that the **next meeting** would take place at 8 p.m. on **Tuesday, February 22nd,** when there would be a discussion on "**Some Future Possibilities in the Design of Instruments for Measuring Illumination** (with special reference to photometers depending on physical and Chemical methods).

NEW MEMBERS.

THE names of applicants for membership read out at the previous meeting on November 23rd were formally announced at the last meeting on December 10th and these gentlemen were formally declared members of the Society.

In addition, the names of the following gentlemen have been duly submitted to the Council and were read by the Hon. Secretary at the last meeting :—

Freeman, L.	Electric Contractor, 156, Whitechapel Road, LONDON, E.

SOME PRINCIPLES IN INDUSTRIAL LIGHTING

(With special reference to the First Report of the Departmental [Home Office] Committee on Lighting in Factories and Workshops).

By J. S. Dow

(Introduction to Discussion which took place at a Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, on Tuesday, January 11th, 1916, at 8 p.m).

In these introductory remarks the object has been to show, by a few typical examples, how the requirements of the Home Office Departmental Committee's Report on Factory Lighting can be readily met by modern methods, and to discuss a few of the data on which calculations of illumination are commonly based.

The discussion should thus be supplementary to that at our first meeting this session (November 23rd). Since that date Vol. III. of the Report, containing the account of the observations in factories, has appeared. The contents of this new volume deserves to be closely studied and should be of great value for reference for years to come; the volume contains by far the most complete account yet published of lighting conditions prevailing in the engineering and textile industries.

As a starting point it is convenient to recall the definitions applying to the suggested general statutory provision "*requiring adequate and suitable lighting in general terms in every part of a factory and workshop.*"

"Adequate and suitable lighting," it is suggested, should comply with the following requirements:—

(1) Adequacy.

(2) A reasonable degree of constancy and uniformity of illumination over the necessary area of work.

(3) The placing of shading of lamps so that the light from them does not fall directly in the eyes of an operator when engaged on his work, or when looking horizontally across the workroom.

(4) The placing of lights so as to avoid the casting of extraneous shadows on the work.

In addition, there are the provisions 2—7 in the Report, relating mainly to the minimum degree of illumination (0.05—0.4 foot-candles, according to circumstances), which is considered necessary in the interests of safety.

Provision of Required Illumination.

As the Committee have not yet been able to undertake to frame standards of illumination required for various kinds of work, one can only discuss the first term, adequacy, in relation to the general contents of the three volumes of the Report. It may be presumed that the amount of light for carrying on work would only be deemed inadequate when it was obviously below the standard usual for the process in question, and manifestly a hindrance to the worker. We have, however, in Vol. III. excellent information as to the conditions which already exist. One of the first things which strikes one in reading this data is the variety in the amount of illumination afforded in different factories for similar processes. It is evident that a general agreement as to standards would be very helpful in removing these anomalies. Lighting experts would probably agree that the *average* values of illumination recorded in these tables could be quite easily provided by modern methods without undue expense; possibly these averages might furnish a rough indication as to the amount of illumination desirable for the class of work, thus paving the way for the standards which the Committee have ultimately in view.

In many cases, both the illumination at the point of work and the illumination on the floor are stated. After examining these figures one appreciates the wisdom of drawing a distinction between the general illumination necessary in the interests of safety and the illumination for the carrying out of work. The existence of a moderately high illumination at floor-level does not imply that the illumination on the work is ample. Conversely one may find a high illumination on the work but very little on the floor, especially when the point of work is a good distance from the floor and the sources of light are placed close to the work. On the other hand, when the nature of the work and the arrangement of the machines render it desirable to aim at a high general working illumination throughout the room, one usually provides this illumination by means of sources mounted near the ceiling. In such cases the mere fact of providing adequate illumination for the work should ensure that the minimum value in the interests of safety and convenience will be everywhere exceeded.

These conditions are probably more typical of factories in London than the mills and workshops, covering a very extensive area, in the provinces. I think, however, that even in large covered areas, where there are spaces between the points where work is done, and where it would be uneconomical to flood the entire floor-area with light, there ought to be no difficulty in providing sufficient to ensure a minimum of 0.25 foot-candles ; and in practice 0.5 foot-candles might be aimed at. Probably there are few cases in which a system of general lighting would be installed with the deliberate intention of producing an even general illumination of this value. The illumination would be necessarily somewhat uneven, the main lighting being of the localised-general character, helped out by occasional units when the illumination was inclined to fall too low. The conditions would then resemble those met with on a platform in the tube railways. I think most people would agree that this illumination is ample from the standpoint of safety : it is probably at least twenty times that considered ample when the first tube was opened !

In order to illustrate the full manner in which the data are presented in Vol. III. of the Home Office Report I am reproducing two typical pages (pp. 44, 45).

The table on p. 45 is chiefly interesting because it shows how high values on the work (2.4—5.8) may coexist with much lower values (0.4—0.58) on the floor.

The other page is useful as showing a case where values on the floor (in this case 0.2 ft. candles), in the neighbourhood of those required by the Committee, were considered sufficient from the standpoint of safety and conveinence.

From the discussion at the meeting on November 23rd, it would appear that the general illumination prevailing in modern factories is apt to be over-estimated. A general illumination of 3 foot-candles appears to be extremely rare, as is shown by the following table, taken from the Departmental Report (Vol. I., p. 42) :—

—	Percentage of Observations lying below the following values of illumination.							
	Below. 0.25 ft. c.	Below. 0.5 ft. c.	Below. 0.75 ft. c.	Below. 1.0 ft. c.	Below. 1.25 ft. c.	Below. 1.5 ft. c.	Below. 1.75 ft. c.	Below. 2.0 ft. c.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Foundries	36	63	76	85	90	93	95	96
All Factories, excluding Foundries ..	24	52	71	83	91	96	97	98
All Factories, including Foundries ..	28	55	71	82	88	93	96	97

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Industry.—Flax spinning and linen weaving.	Room No.—19E
Process.—Preparing.	*Height*—10 ft. to 16 ft.
Operatives.—27.	*Floor space*—8,500 sq. ft.
Date.—18th-19th December 1913.	*Cubic contents*—110,093 cub. ft.

Description of Means of Lighting.

WINDOWS.	POSITION		ORIENTATION.			
	Roof	Wall.	N.	S.	E.	W.
Number	1	15	—	—	15	1
Total area (sq. ft.)	870	360	—		360	870
Distance— (*a*) base to floor	—	—	—	—	4′ 3″	In roof
(*b*) top to ceiling	—	—	—	—	1′	
Kind of glass	Mostly clear		—	—	—	—
Fraction of unobstructed sky visible from centre of room	0	0	—	—	—	—
Angle of obstruction by neighbouring buildings	—	—	—	—	40°	—
Distance from nearest building	—		—		50′	—

ARTIFICIAL LIGHT SOURCES	System 1.	System 2.	System 3.
Kind	Electric glow lamps.		
Number	70		
Candle-power	16		
Height from floor	6′		
Distance between— (*a*) rows	11′ to 16′		
(*b*) units in same row	12′		
Adjustable	No		

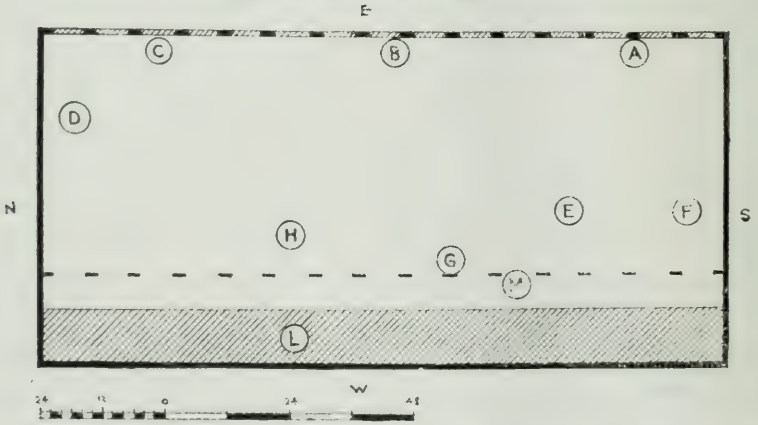
Results of Observations.

Point on Plan.	POSITION	Natural Light				Artificial Light. Illumination (Foot-candles)	Committee's Comments. (*Opinion as to adequacy, &c.*)
		Hour	Illumination		Daylight Factor (per cent.)		
			Inside.	Outside.			
A.	Roving frame	1.18½ p.m.	1·1	96	1·2	0·33	*Inspected by Daylight.* Poor light at centre due to side window lighting and obstruction by machines. 0·05 to 0·5 per cent. daylight factor. *Inspected by Artificial Light.* The artificial light was by exposed carbon glow lamps and was not pleasing. Illumination on frames 0·2 to 0·8 foot-candle. Illumination in gangway 0·2 foot-candle. This gangway was wide and without shadows, and the illumination appeared sufficient in the opinion of the Committee, in fact seemed above the minimum necessary.
B.	„	1.19½ „	1·5	105	1·5	0·24	
C.	Floor	1.20 „	1·6	110	1·5	0·23	
D.	Drawing frame	1.21 „	0·11	105	0·10	0·77	
E.	Floor	1.24½ „	0·03	105	0·03	0·20	
F.	Drawing frame	1.25 „	0·06	96	0·06	0·45	
G.	Roving frame	1.26 „	0·24	100	0·24	0·22	
H.	Floor	1.27 „	0·48	90	0·53	0·22	
K.	Drawing frame	1.28 „	2·5	96	2·7	0·16	
L.	Floor	1.28½ „	5·8	105	5·5	0·16	
M.	Drawing frame	1.29 „	3·4	105	3·2	0·51	

Meteorological Conditions.—Atmosphere hazy, sky overcast, very dull (19.12.13.)

Plan of Room, with Observation Points indicated.

(Shaded parts represent windows.)



Reproduced from Vol. III., Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops, p. 30, by permission of The Controller of His Majesty's Stationery Office.

Industry. Linen weaving.	**Room No.**—24A.
Process. Weaving.	*Height.*—12 ft. to 15 ft.
Operatives.—185.	*Floor space.*—27,000 sq. ft.
Date.—22nd-23rd December 1913.	*Cubic contents.*—365,000 cub. ft.

Description of Means of Lighting.

WINDOWS.	POSITION.		ORIENTATION.			
	Roof.	Wall.	N.	S.	E.	W.
Number	14	—	14	—	—	—
Total area (sq. ft.)	5,800	—	All in roof (q.v.)	—	—	—
Distance—						
(a) base to floor	—	—		—	—	—
(b) top to ceiling	—	—		—	—	—
Kind of glass	Ribbed	—	—	—	—	—
Fraction of unobstructed sky visible from centre of room	1	—	—	—	—	—
Angle of obstruction by neighbouring buildings	—	—	—	—	—	—
Distance from nearest building	—	—	—	—	—	—

ARTIFICIAL LIGHT SOURCES.	System 1.	System 2.	System 3.
Kind	Electric glow lamps.		
Number	480		
Candle-power	25		
Height from floor	5′		
Distance between—			
(a) rows	9′		
(b) units in same row	6′		
Adjustable	No		

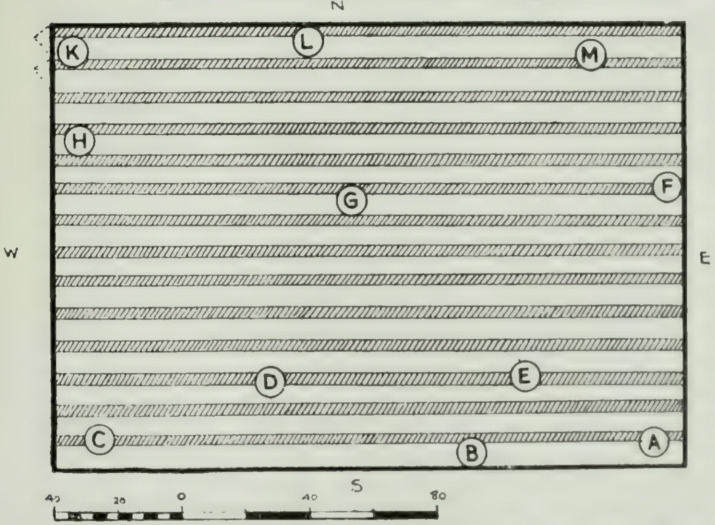
Results of Observations.

Point on Plan.	POSITION.	Natural Light				Artificial Light.	Committee's Comments.
		Hour	Illumination.		Daylight Factor (per cent.)	Illumination (Foot-candles).	(*Opinions as to adequacy, &c.*)
			Inside.	Outside.			
A.	Cloth on loom	10.22½ a.m.	4·2	480	0·8$_6$	4·0	*Inspected by Artificial Light.* One 16-candle lamp with deep shade to each loom, giving from 2 to 4 foot-candles on loom. Very satisfactory system, free from glare. Some unshaded lights were compared with properly shaded ones and the difference in comfort and efficiency was marked. An excellent installation.
B.	Floor	10.23½ „	5·3	480	1·1	0·58	
C.	Cloth on loom	10.24½ „	8·4	480	1·7	1·8$_5$	
D	„ „	10.25½ „	13·$_6$	480	2·8	4·0	
E.	„ „	10.27 „	12·$_5$	480	2·6	2·2$_0$	
F.	Floor	10.28 „	3·9	540	0·7$_2$	0·40	
G.	Cloth on loom	10.29 „	16·$_0$	510	3·$_3$	4·6	
H.	„ „	10.30 „	12·$_5$	510	2·5	5·8	
K.	„ „	10.31 „	5·5	510	1·1	2·4$_5$	
L	Floor	10.32 „	3·8	540	0·7$_0$	0·58	
M	Cloth on loom	10.33 „	13·$_5$	510	2·6	4·3	

Meteorological Conditions.—Atmosphere hazy; sky blue, sun. (23.12.13.)

Plan of Room, with Observation Points indicated.

(Shaded parts represent windows.)



Reproduced from Vol. III., Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops, p. 12, by permission of The Controller of His Majesty's Stationery Office.

It will be seen that 2 foot-candles was only attained in 3 per cent. of the factories visited, while 28 per cent., or nearly a third, fell below the minimum of 0.25 foot-candles suggested. If, therefore, all factories were brought up even to this level a substantial improvement would have been made.

Before leaving the question of the minimum intensity of illumination required from various standpoints, reference may be made to two publications in which this question has been discussed. There is firstly the well-known booklet on Industrial Illumination, issued some years ago by the National Electric Light Association in which the usual practice for various trades was summarised in a very admirable manner. After examining these figures closely, one is inclined to think that perhaps it is hardly necessary, with our present knowledge, to attempt to discriminate quite so closely between the requirements of different operations as in this production. The following rough classification contained in the recent Code prepared by a committee of the American Illuminating Engineering Society might perhaps serve as a useful guide :—

Class of Work.	Minimum illumination (ft.-candles.)	Desirable illumination (ft.-candles.)
Storage, passage-ways, stairways, and the like	0·25	0·25—0·5
Rough manufacturing and other operations	1·25	1·25—2·5
Fine manufacturing and other operations	3·5	3·5 —6·0
Special cases of fine work	—	10—15

The first value happens to be near with that suggested in the Report of the Departmental Committee for the illumination necessary in the interests of safety. The other three values come under the head of illumination for the carrying out of work. It may be suggested that almost all industrial operations might be classified under one of these heads, so far as the amount of illumination required is concerned.

It should be particularly noted, however, that merely specifying a certain illumination on the work is not enough to secure "adequate and suitable lighting." The illumination must also comply with the requirements stated above as regards uniformity of illumination over the working area, avoidance of glare, and avoidance of inconvenient shadows.

These are all questions which have often been discussed at meetings of our society, and have received the attention of firms interested in illumination. The provision of a uniform illumination is mainly a matter of arranging the lighting units at suitable distances according to their distribution curves, and in cases where it is necessary to light a large area equally at all points a high standard of uniformity can be obtained. In such cases a variation of not more than 25 per cent. on the work might perhaps be anticipated.

In many cases, however, even a considerable variation in illumination would not be objectionable from the standpoint of efficiency and comfort of workers—provided the illumination on the work always exceeds a satisfactory value ; in other an *excess* of illumination in some places is not as a rule detrimental to work, but a variation in the form of too low an illumination at certain points would be.

Avoidance of Glare.

The next consideration, the avoidance of glare, is an exceedingly important one. This is the requirement which, of all others, is apt to be disregarded in factory lighting, and Vol. III. of the Home Office Report contains frequent objections to installations on this ground. Yet, so far as those who scheme out factory installations are concerned, there is now general agreement that glaring points of light within the range of vision should be avoided, and the explanation of defective installations lies more often in the indifference of the public who have not yet learned that exposed brilliant lights are necessarily wasteful, and even insist on them. No doubt the issue of the Home Office Report will have a good influence in this respect. I think, however, members of the Society will agree that by the aid of modern appliances it should be practicable in almost every variety of installation to comply with the Committee's sug-

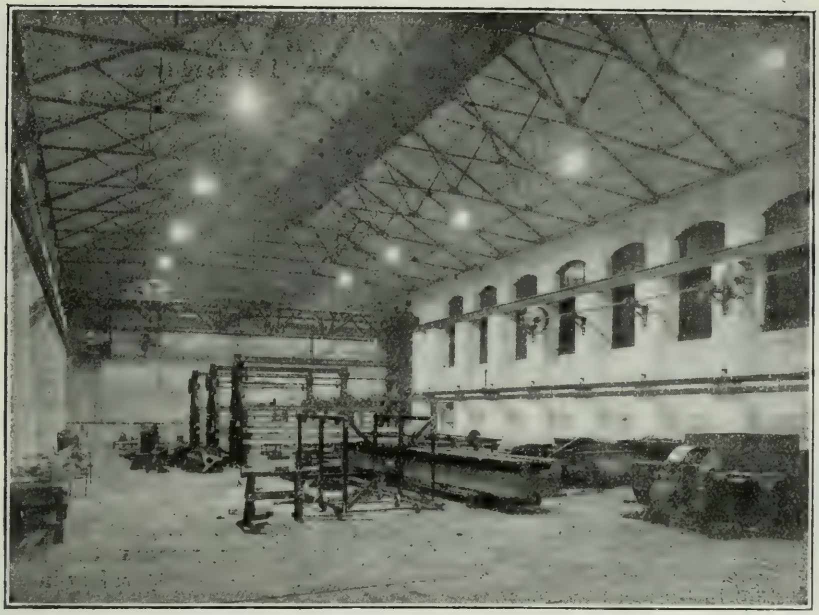


FIG. 1.—Overhead Electric Lighting in an erecting shop, 160 ft. long. 63 ft.wide, 36 ft. high, by two rows of six 400-watt tungsten lamps in reflectors at a height of 33 ft. Consumption approx. 0·5 watts per square foot. Illumination 2·2 ft.-candles.

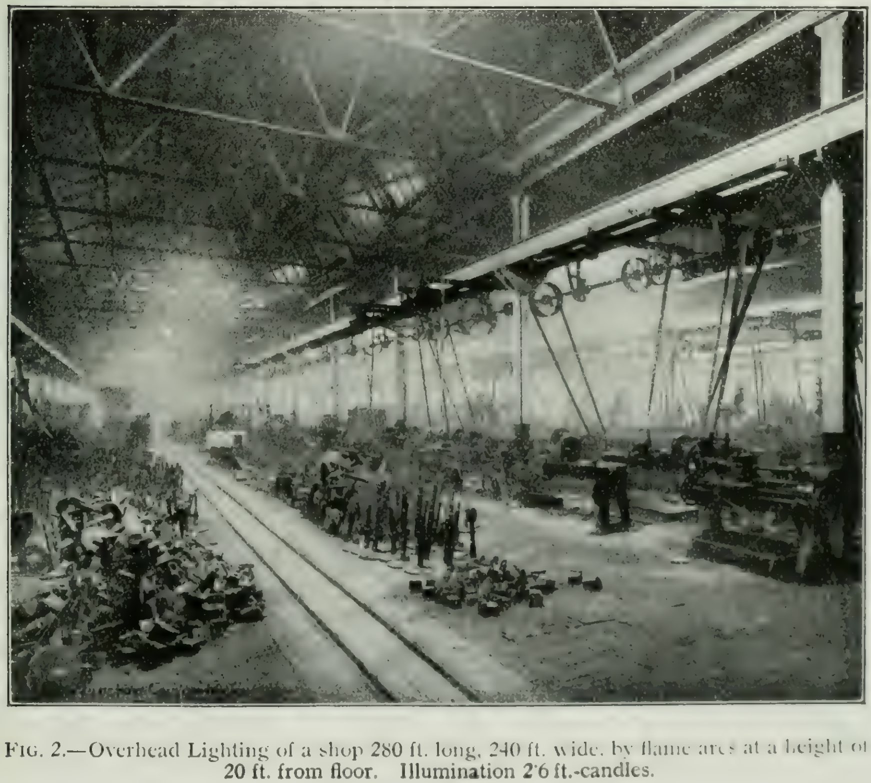


FIG. 2.—Overhead Lighting of a shop 280 ft. long, 240 ft. wide, by flame arcs at a height of 20 ft. from floor. Illumination 2·6 ft.-candles.

gestion, namely, "the placing or shading of lamps so that the light from them does not fall directly on the eyes of the operator when engaged on his work or when looking horizontally across the workroom." The installations where it would probably be most difficult to meet this requirement are those carried out in rooms with rather low ceilings. However, seeing that the use of an appropriate reflector almost invariably tends to *increase* the light on the work, there is clearly no hardship in asking that such lights should be screened.

Avoidance of Inconvenient Shadows.

The last requirement, relating to the avoidance of inconvenient shadows, is clearly one whose application will have to be studied by practical experience. For the present, no doubt it would serve chiefly to enable inspectors to advise managers of factories to make small adjustments in the positions of lamps, &c., in cases where the wrong direction of light, by causing a deep shadow, was obviously causing inconvenience to a worker or a possible source of danger As instances, one might mention the presence of an inconvenient shadow at a cutting edge or circular saw, or the shadows thrown by projecting masses of machinery causing moving parts to be in semi-darkness.

I am inclined to think, however, that the part played by shadows in industrial lighting deserves much fuller investigation than it has yet received. One often finds that an objection to a system of lighting on the ground of insufficiency is really due to the light coming from the wrong direction; and I believe that the differences in the requirements of different industrial processes are based even more on shadow than on intensity of illumination. Lighting experts should bear this in mind, when they meet apparently unreasonable prejudices on the part of clients. The latter sometimes express an objection to some method of lighting, which they are unable to explain completely, but which on closer examination proves to be well justified. In rooms filled by different classes of machines such considerations may considerably disarrange a regular system of spacing the lamps.

Speaking generally, the requirements as regards "adequate and suitable lighting" would be readily endorsed by lighting engineers, and on pages 47, 50, 51, 55, and 57 a few typical illustrations of factories, lighted by gas and electricity respectively are reproduced in order to show that these requirements are easily met.

Prediction of Illumination.

Assuming, however, that in good installations an illumination is commonly provided which more than meets the Committee's requirements, the next question is whether it is practicable to determine in advance the actual illumination that will result from a given arrangement of lighting units in specified positions; to make sure, in fact, not only that the requirement as regards the minimum general illumination for safety in working areas is satisfied, but that the illumination at the point of work is also ample.

To those who are responsible for the planning of lighting installations it may seem almost superfluous to raise this question; and in fact it was conclusively shown in a paper by Mr. Clinton before this Society in 1914* that by taking sufficient care the illumination obtainable may be calculated with considerable accuracy. But the fact that it was recently stated in a leading technical journal that "no one can calculate beforehand how much light will be required and how much will be obtained by any suggested arrangement," shows that the resources of modern illuminating engineering in this respect are not sufficiently widely known. The view that illumination can be pre-determined with quite sufficient accuracy for practicable purposes was endorsed by a number of witnesses before the Committee, representing both gas and electric lighting. I propose to give a brief description of some of the methods most commonly used for this purpose, dealing, however, only with the simplest aspects of the subject, and without entering into the more complete systems adopted by companies having very full data at their disposal.

A few years ago, it would certainly have been difficult for any engineer to make these calculations without preliminary tests of the lighting units he proposed to employ. But at the present time leading companies issue polar curves of light distribution of their standard units, and it is therefore easy to calculate not only the illumination immediately under the lamp when hung at a prescribed height, but also the illumination at a given distance from it. If a lamp hung at a height *h*, gives a candlepower I in the direction immediately below it, the resultant illumination under this lamp is I /h^2. If we next select a spot at a distance *r* from the point immediately below the lamp, and if the candlepower in that direction is I_θ the resultant horizontal illumination is

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* *Illuminating Engineer*, April, 1914, p. 189.

$$E = \frac{I_\theta}{h^2} \cos^3\theta = \frac{I_\theta . h}{(h^2+r^2)^{\frac{3}{2}}}$$

These are formulae which are perfectly familiar to lighting engineers, and can be applied by anyone with engineering knowledge. If we are dealing with two lamps in a row we can by using the above formula obtain the illumination from either at any point between them, and, by adding up, the resultant illumination due to both units.

The aim of the designer of a lighting installation is, as a rule, to adjust the distance between the two lamps so as to secure approximately even illumination between them; or, if he does not wish to do this, he can, by the above calculation, readily predict what the approximate variation will be.

Makers of modern lighting appliances, however, have simplified these calculations by furnishing information regarding the best relations between the height and distance apart of lamps in order to secure even illumination. Three distinctive types of distribution curves, corresponding with "extensive," "intensive," and "focusing" reflectors have been adopted, and anyone who adopts these methods can see from the data provided what the direct illumination with the lamps at a given height may be. It is true that in practice one cannot always adhere to these rules exactly, but as a rule the deviation resulting from a departure need not be large, and can, with a little trouble, be allowed for.

(In passing I should like to mention that, while one can easily get full information of this kind regarding direct lighting, similar data for indirect lighting are not usually obtainable. Would it not be practicable, in this case, to furnish data for the spacing of units, and possibly even approximate information as to the resultant illumination? Those who have had experience of indirect installations can form a fair estimate of the results from a given arrangement, but many engineers are less certain of the results, than in dealing with direct lighting.)

It will be observed that the above data refer to the direct illumination from the lighting units, and take no account of light reflected from walls and surroundings. It is here that less certainty is felt, although the experienced can form a very fair estimate of the added illumination, with a known type of lighting. In some cases an allowance may be made, but if little is known as to the nature of the interior in which the lights are to be installed, it is a safer plan to regard the added light by reflection as a margin of safety, with the comforting knowledge that the illumination will certainly not fall below the estimated value, and may exceed it by 25 or even in exceptional cases 50 per cent.

The general tables frequently given for calculating the effect of surroundings are, in the writer's opinion, not very valuable, because they do not take into account the size of the room or the variations arising through the use of particular types of units. A somewhat better method is furnished by some diagrams recently published by Mr. S. W. Cuttriss for E, I, and F reflectors, which profess to take into account reflection from average surroundings.*

The following rough rule, given in the American "Code on Factory Lighting," is worth bearing in mind:—

"With modern lamps roughly one candlepower per square foot produces an effective illumination of 3 foot-candles when the lamps are arranged according to the uniformly distributed overhead system, with mounting heights ranging from 12 to 16 ft. above the floor, and when the light is directed from the lamps to the work in an efficient manner."

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* *Elec. Engineering*, September 9th, 1915.

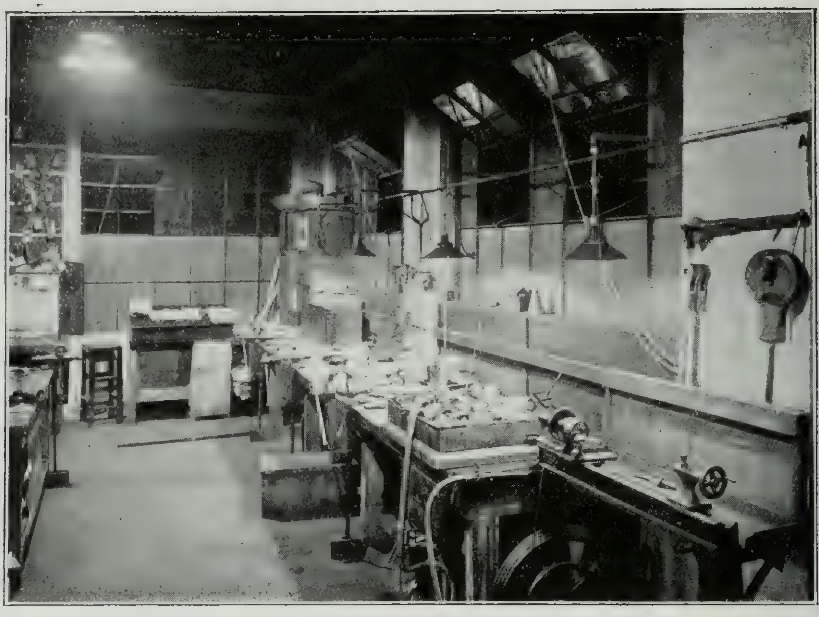

FIG. 3.—Gas Lighting (low pressure) of a small workshop with well-screened lamps. Illumination, provided by local lights, on the benches on the right, 13—20 ft.-candles ; on the tables in the centre of the room the general illumination was 5·7—10.5 ft.-candles ; at floor-level in gangway, 6·1—7·1 ft.-candles (see also *Illum. Eng.*, Aug. 1915, p. 339.

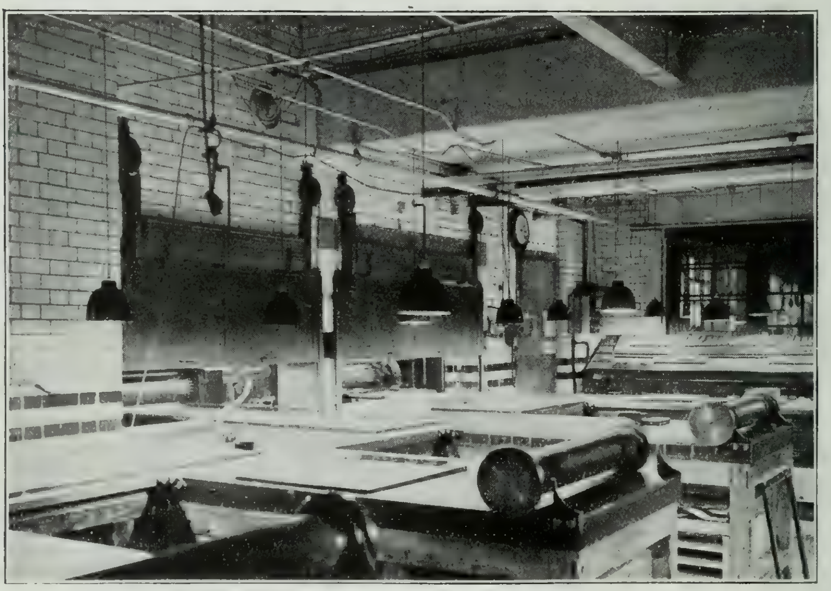

FIG. 4.—Local Electric Lighting in a Printing Works. Illumination on the tables, 7—11 ft.-candles ; in gangway, 1—3 ft.-candles (approx.). The lighting here is on an exceptionally generous scale and the illumination was aided by reflection from light walls and ceiling. In another room, also well lighted but with less powerful lamps, values on the floor near 0·5 ft.-candles were recorded.

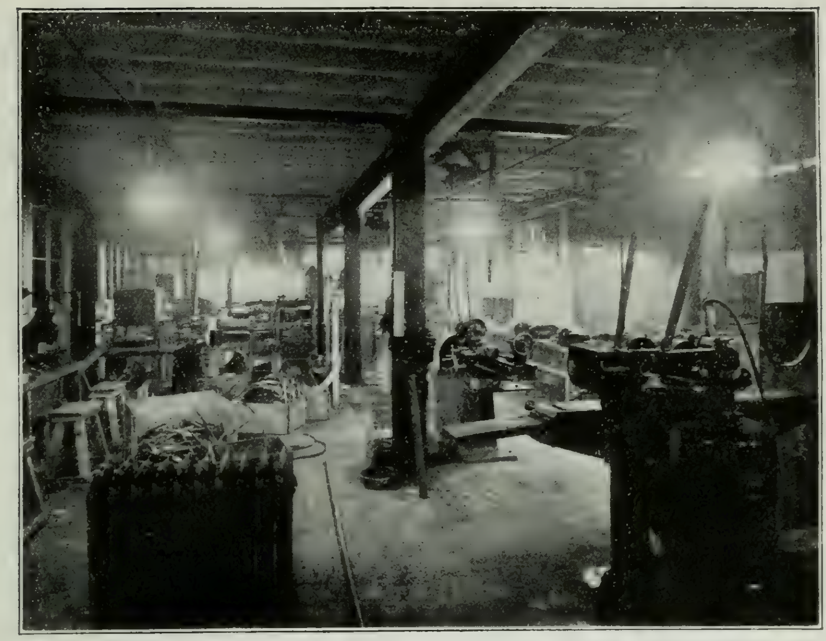

FIG. 5.—Typical general gas lighting (low pressure) in an engineering workshop.

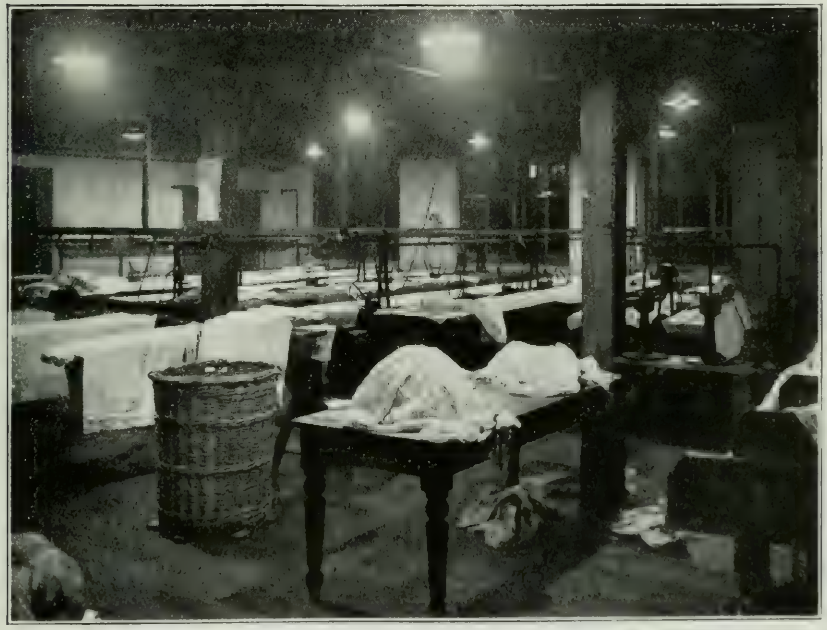

FIG. 6.—Gas lighting (low pressure) in a laundry. On benches over 4 ft.-candles; in gangway, 1·66 ft.-candles.

(For other examples of low pressure gas lighting see *Illum. Eng.*, Aug. 1915., p. 430.)

The writer as the result of tests in average interiors during recent years has been accustomed to reckon general lighting installations on the following approximate basis. Naturally these data only apply to cases in which an even general illumination is aimed at, and typical properly designed lighting units are used; they are also subject to some modification when one is dealing respectively with very large or very small interiors. But they are fairly useful as a rough preliminary guide :—

Illuminant.	System of Lighting.	Specific consumption per lumen on working plane.
Gas		cub. ft. per hr. per ft.-candle per sq. ft. illuminated.
	Direct :—	
	Low pres.	0·01 —0·02
	High pres.	0·003—0·1
	Indirect :—	
	Low pres.	0·02 —0·04
	High pres.	0·005—0·02
Electricity		Watts per ft.-candle per sq. ft. illuminated.
	Direct :—	
	Tungsten lamps	0·2 —0·3
	White arc and half-watt lamps	0·1 —0·2
	Flame arc	0·05—0·1
	Indirect :—	
	Tungsten lamps	0·4 —0·6
	Arc and half-watt lamps	0·2 —0·4

In these cases the illumination referred to is that on the working plane, *i.e.*, the level of the tables and benches where work is carried on. But it must not be inferred that the light directed on the surroundings is wasted. In many cases where the illumination of large vertical surfaces, diagrams, shelves, &c., is important the additional illumination shed in these directions by indirect and semi-indirect systems is a compensating advantage for the relatively lower illumination, for a given energy expenditure, on the working plane.

The necessity for allowing a certain amount of light to surroundings is one explanation why what is called the "utilisation efficiency" (the percentage of the total flux of light from the lamp received on the working plane), works out to a somewhat low value, frequently not more than 40 or even 30 per cent. Another explanation is found in the fact that, with existing filaments, there is a limit to the degree of concentration one can obtain from an ordinary reflector; possibly were we to use sources more nearly approaching a point "superfocusing" effects could be obtained, and for certain classes of work this might be an advantage.

It may be observed, however, that the proportion of the total amount of light reaching the working plane tends to increase as the area illuminated increases (assuming that lamps are kept at the same distance apart). For this reason one finds that in very extensive installations higher values of illumination are obtained than one at first sight would expect. At the other end of the scale one finds that very small interiors, with light walls, also give high results because much of the light emitted sideways is redirected on to the working plane.

General, Local, and Localised General Lighting.

Both in framing rules for the calculation of illumination, and in devising recommendations regarding the arrangements of lamps with respect to work, the avoidance of glare, &c., one has to draw a distinction between general and local lighting. There is no doubt that the line of demarcation between these two methods has shifted considerably during recent years, and it occurred to me that it would be of interest to conclude this paper with a few remarks on this subject. It has been customary in the past to distinguish between the respective fields for employing for "general," "localised-general," and "local" lighting. General illumination is admittedly the best system for a workroom when it is desired to illuminate the entire area of the room equally well all over. When a room is almost completely filled by rows of workers engaged on identical operations one should clearly aim at a well-diffused flood of illumination over the working area. It was formerly the custom to treat such rooms by pendant lamps over each individual machine or group of machines, to allot so many lamps per bench, &c., the lights being usually of relatively small candlepower, and mounted only a few feet above the working level. The development of more highly efficient gas and electric units during recent years has quite changed this problem. The tendency now is undoubtedly to use more powerful lamps, if necessary, in suitably concentrating forms of reflectors, and to place them high up near the ceiling, at the same time taking full advantage of the reflecting power of light surroundings. This " overhead system " does away with long lengths of wire or piping, and leaves the room completely clear so that the foreman can see from end to end. This system is advantageous from the standpoint of avoiding inconvenient shadows, and it has the great merit that the position of benches and machinery can be altered without its being necessary to rearrange the positions of lamps.

In rooms that are satisfactorily lighted on the above system the illumination requisite in the interests of safety will almost invariably be exceeded throughout. If the illumination is well diffused, and provision for local lighting of certain machines is made, one would even recommend general lighting in rooms which are filled with machines of different character, the floor space being completely occupied.

Local lighting is still regarded as essential in cases where the work is of a specially delicate or complicated character. The rise in the standard of illumination during recent years, and the development of better types of reflectors, has certainly resulted in general lighting being applied in many cases where local lighting would once have been considered necessary. But there still remain many operations where a local light is needed, chiefly cases where the illumination must reach an exceptionally high value—such could not economically be provided throughout the entire room, or when the efficiency of the work depends on the play of light and shade, and the craftsman likes to alter the position of the material with regard to the light in order to detect small irregularities on its surface.

A good example of the transition stage from local to general lighting is afforded by offices. Formerly in large offices, banks, &c., every clerk had his own individual shaded lamp. More recently general diffused illumination has been introduced, and the development of illuminants certainly makes this system much more practicable than in days gone by. The local system is, however, still preferred in many offices, and it remains to be seen whether it will be displaced entirely. One point in connection with local lighting may be insisted upon, the provision of a moderate general illuminant in addition to the strong local lighting, so as to avoid undue contrast between the illumination of the work and the surroundings. A general value of at least 0.5—1 foot-candles might be suggested. On the other hand, when general illumination is used one must guard against too little contrast ; one frequently hears it said that the eye likes to be " rested " by the gaze being transferred from the brightly illuminated work to the subdued surroundings. The physiological basis of this problem is still obscure and requires further study.

It is sometimes said that the so-called " localised-general " lighting is destined to disappear entirely, and that presently we shall have only local or general illumination, or a combination of the two. At the present time, however, there seem to be classes of rooms where something resembling localised general lighting is inevitable. For example, in rooms where the ceiling is low it may be impracticable to produce well diffused general illumination throughout the room, and the right course is therefore to attend to the requirements of the various machines, if necessary, supplementing this system by extra intermediate lights where necessary to bring up the floor-illumination to a safe level. Individual lights for certain machines or tables are again used in those workrooms (more common in provincial and country districts than in London), where large portions of the floor are left unoccupied, and the manager does not see the necessity for providing a strong illumination except at the places where actual work is going on. Basement printing works often fall in this class, partly on account of the nature of the work, partly owing to the ceilings being in general low. In other cases the nature of the work makes it necessary to leave large free spaces for material to be transferred from lifts and unpacked; in yet other cases it may happen that only certain machines are used at the same time, and the whole floor is never at work simultaneously. In such cases the lighting must be "sectioned," even if on the general system.

As an instance of an industry where local lighting seems likely to be replaced by general illumination, one may take clothing factories. Here we usually find that an entire room is occupied by rows of sewing machines doing almost identical operations, but the illumination requires to be exceptionally high, especially when dark materials are used, and local lighting has therefore been hitherto largely employed. In one of the very latest factories now working on khaki material, general lighting with half-watt lamps has now been adopted.

In one room the consumption is about 1.25 watts per square foot of floor area, and the general illumination is 10—12 foot-candles. (This value is somewhat higher than is actually needed, owing to the fact that at the time the installation was made only 300 watt "half-watt" lamps were available.)

In the second room the consumption is 0.75 watts per square foot, and the illumination 7—9 foot-candles. The provision of such a high general illumination is somewhat unusual but has proved very advantageous, and is adapted to the finest work and the darkest materials. The spacing of the lights in appropriate reflectors, and the good reflection from the light surroundings, enables any ordinary kind of work to be done, whereas with the old system of local lighting there were certain operations (sewing button holes, for example), which were hampered by inconvenient shadows.

In spite of the lavish illumination, the running cost of the lighting is very reasonable. In most industries where highly skilled operations are carried on, the cost of lighting forms only a small proportion of the turnover.

The above example is interesting as a change from local to general illumination. The problem of lighting sewing machines can, however, be met in quite a different

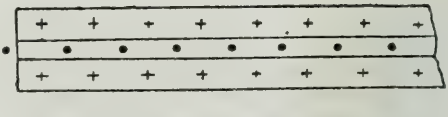

FIG. 7. "Local" Lighting of Sewing Machines.

60 watt lamps in suitable reflectors which completely screen the light from the eyes of the operators, at a height of 2½ feet above table. Note the extra light at end of bench to avoid inconvenient shadows.

Crosses indicate position of machines. Dots indicate position of lamps.

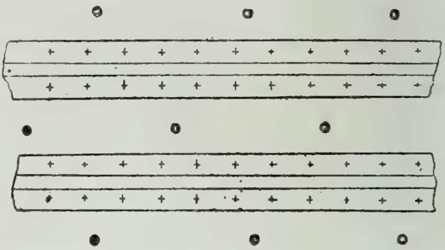

FIG. 8.—General Lighting of Sewing Machine Benches.

200 watt "Half-Watt" lamps 10 feet above floor and 12—14 feet apart, give an illumination of about 8 ft.-candles. Reflectors appropriate for spacing (intensive). Benches are usually about 4½ feet across, and machines 3—3½ feet apart.

A photograph of an installation designed in this manner is shown on the opposite page.

Crosses indicate position of machines. Dots indicate position of lamps.

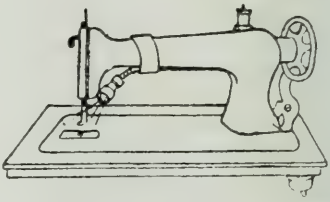

FIG. 9.—A system of Special Local Lighting of Sewing Machines.

A 6-volt 5·5 c.p. glow lamp with small parabolic reflector, placed about 6 inches from the needle, gives very strong illumination of the work, and the light is completely screened from the operator.

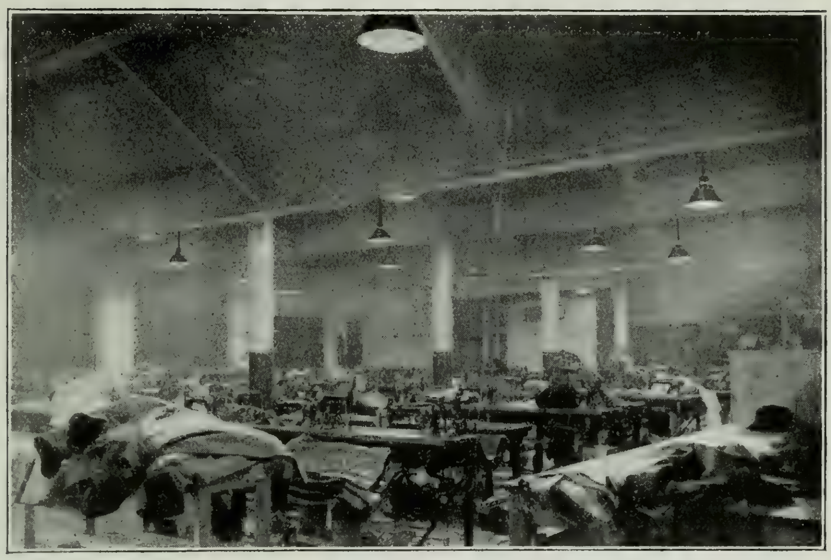

FIG. 10.—Consumption 1·25 watts per square foot. Illumination 10—12 ft.-candles.

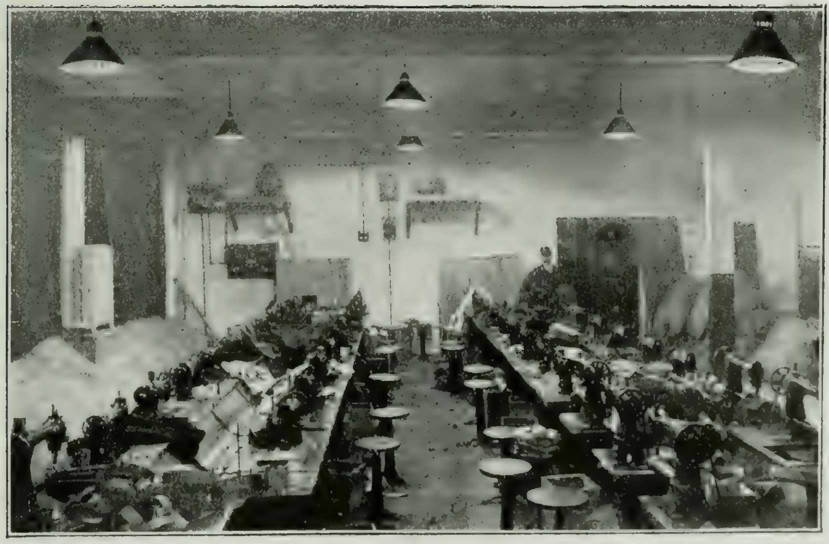

FIG. 11.—Consumption 0·75 watts per square foot. Illumination 7—9 ft.-candles.

Lighting of a Clothing Factory with Half-watt Lamps.

manner, namely, by the use of very small lamps, mounted close to the needle of the machine, so as to constitute a variety of "special local lighting." On this "Permel" system miniature 6 volt, 5.5 candlepower lamps in small parabolic reflectors are placed about six inches from the point of the needle, the lamp being completely screened from the operator and a very strong local illumination obtained. The system is most conveniently applied from an alternating current circuit. The pressure is transformed down to 6 volts; if alternating current is used, one 125 watt transformer will supply 23 machines. The small lamps may also be fed by a rotary converter or even from a battery of accumulators. Naturally the use of such small lamps is a great economy, and the system seems well adapted for very fine work. It is, however, necessary to supplement this intense local illumination by a suitable general lighting, so as to avoid undue contrast with the surroundings and permit supervision of work. This is a good example of a case in which the minimum illumination on the floor, prescribed by the Committee, in the interests of safety and convenience, would be of great importance, quite apart from that provided for the work.

The varied applications of local and general lighting are also well exemplified in machine shops. In an erecting shop a good general illumination is necessary as a basis, and some good examples of the overhead system are reproduced (Figs. 1, 2 and 12). Even here, however, portable lamps may be desirable for close inspection of special work, while it would generally be agreed that lathes and benches require either local or localised general lighting. For fine work, ability to adjust the position of the light is of importance, and in deep boring it may even be an advantage to have a small light which can be actually inserted into the aperture.

In these cases, and likewise in the illumination of drilling and planing machines, the direction from which the light comes is important, and good general illumination alone is probably hardly sufficient. Automatic machinery is really a special case in itself, in view of the fact that the special local illumination is really only required in setting the tool and arranging the work; once the machine is set in operation a moderate general illumination suffices. This illustrates the distinction between "inspective" and "detective" work drawn by the Committee.

Another circumstance that has favoured the use of general illumination for factory lighting is the simplification of machinery and diminution of shafting and belts, owing to the application of local electric driving. Generally speaking, in machine shops where there are a large number of moving belts and overhead shafting general lighting is inapplicable, owing to the interruption and flickering shadows caused by these moving objects; local lighting must therefore be used. The same applies to weaving rooms in textile mills, except that the method in this case might more fitly be described as localised general lighting, seeing that one light is commonly allotted to two or four looms. But here again in the very latest mills the obstruction to light from above has been diminished, and a well diffused system of general lighting might in this case be practicable.

There are many points in connection with industrial lighting, such as the choice of large or small units, the effect on the illumination of deposits of dust on the lighting units, the need for correct colour discrimination in certain trades, &c. In order to keep this introduction within reasonable limits, I have also confined myself to artificial illumination. Vol. III contains very full data on daylight conditions, but these deserve separate consideration.

I should, however, like to conclude these remarks by reference to one other matter—the importance of reflected light from the surroundings. Attention to this point will assist almost all the requirements of the Home Office Committee, and will do much to compensate for unsatisfactory features in the design. This reflected light is most valuable in strengthening the illumination in parts of the room most remote from the lamps, and keeping it above the minimum necessary for safety. In addition, it is now recognised that most objects cannot be completely seen unless they are illuminated from many different directions. It is the

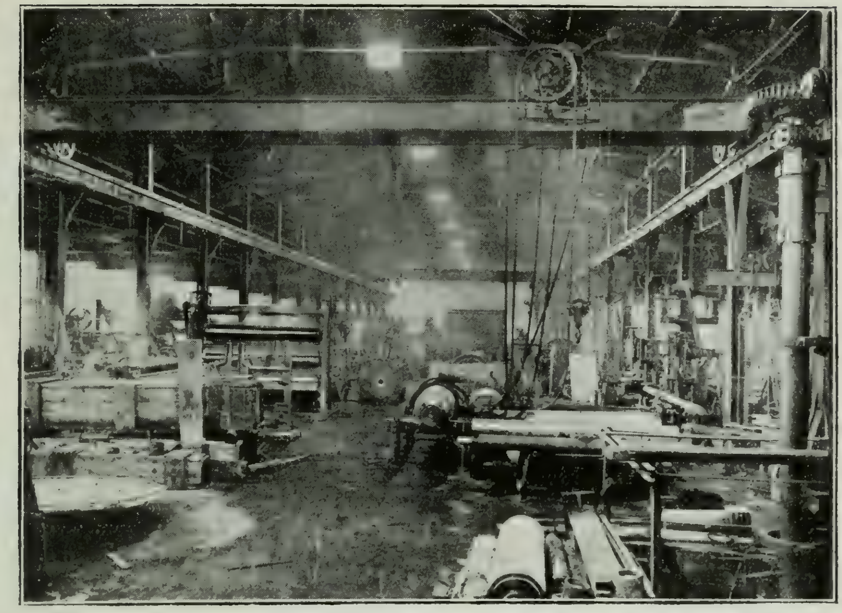

Fig. 12.—Overhead Lighting in Engineering Workshop : general illumination 1·1—1·82 ft.-candles
Illumination on fitter's bench, 8—12·5 ft.-candles.
Illumination on milling machines, 3·2 ft.-candles.
Illumination on lathes, 3·5—8·5 ft.-candles.

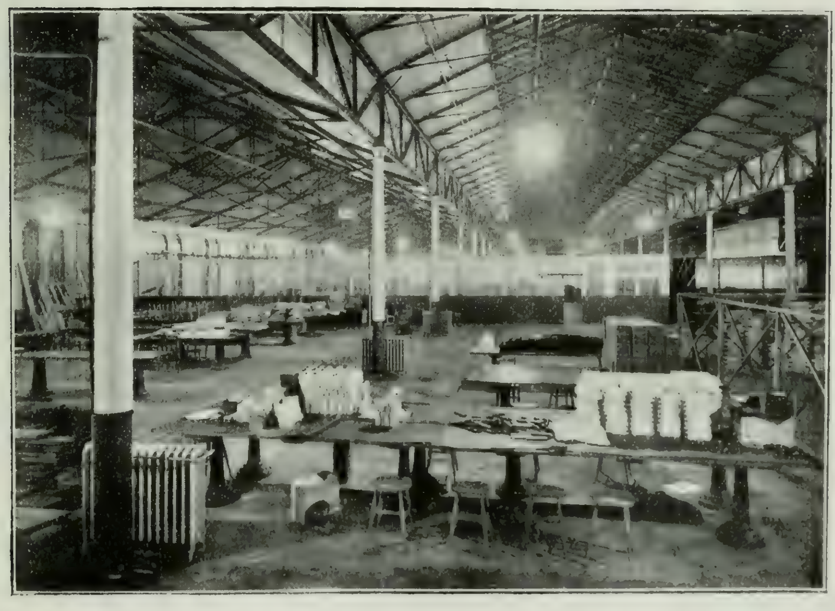

Fig. 13.—Swiss Milk Factory (see also *Illum. Eng.*, Aug. 1915, p. 342).
Illumination on floor, 2 ft.-candles ; at points of work, 3·2—5·5 ft.-candles.

Two examples of Modern High Pressure Gas Lighting.

absence of these reflected rays which makes outdoor lighting such a difficult matter, even when the illumination is from a photometric standpoint relatively high and uniform. So well is this recognised that in some factories in the United States, not only the ceiling and walls, but also the floor and the non-moving parts of machinery, are painted in a light colour. Something might also be learned from the prevailing conditions in our streets. The practice of using whitened kerbs might be copied more frequently in the case of platforms, stairways, &c., and in all places where a fall might have serious consequences.

In conclusion special acknowledgment should be made of the courtesy of the following firms, who, among others, have furnished photographs and data regarding lighting installations :—The Gas Light & Coke Co., the South Metropolitan Gas Co., Messrs. Jas. Keith and Blackman, Ltd., Holophane Ltd., The British Thomson Houston Co., Ltd., and Benjamin Electric Ltd.

DISCUSSION.

The CHAIRMAN, in expressing the thanks of the Meeting to Mr. Dow for his very comprehensive, interesting and well illustrated paper, remarked that it was not so much controversial as informative; it did not call so much for discussion as for study. At any rate that was his opinion, although it might not be shared by others who were present, and it was possible—indeed he hoped—that there would be an interesting discussion.

The only point he himself had noted was Mr. Dow's query as to whether local or general lighting was desirable for offices and banks. In his opinion with the possibility of getting good general illumination at a moderate cost, the desire for local illumination would largely die out, but it all depended upon the intensity of the application to the work that was called for, because in the case of work demanding intense concentration of the eyes for lengthy periods as in sorting letters, the workers usually found that it was much more restful to be able to glance up occasionally from the work to darker surroundings, rather than to have the surroundings and the work equally illuminated. He believed in the Post Office it was found necessary at the request of the sorters to moderate the general lighting in order that they might get rest for their eyes when they looked away from their work. His own experience in office work was that good general illumination was sufficient. His office was lighted by a lamp in the ceiling perfectly satisfactorily, and he had done away with the old desk lamp which at one time was thought indispensable.

Mr. H. C. WHEAT said he was pleased to be able to show a number of slides confirming many of the points mentioned by Mr. Dow—for instance, the suitability of general illumination for a large number of situations without the necessity for local lights, and the fact that all lamps could be placed high and properly screened without loss of efficiency.

A point on which Mr. Dow did not touch, and one of paramount importance, was the question of diffusion. This was a difficult thing to define or demonstrate, but the speaker showed slides made from photographs of a demonstration, in which it was possible to compare the shadows from two similar lamps, one equipped with a diffusing appliance, and one without. It could be seen from these that there was a very great difference in the character of the shadows. In the one case they were hard, with clearly defined edges, and in the other soft with a gradual change from dark to light. Good diffusion is an essential of satisfactory lighting, particularly where this takes the form of general illumination.

Mr. Wheat also remarked that the measurement of illumination on a horizontal plane alone was not a sufficient indication of the value of an installation. Generally speaking, vertical illumination was equally important.

Some of the speakers appeared to infer that the replacement of local lights by general illumination was something new and untried. This, however, was not the case, and a number of slides were shown illustrating installations employing only general lighting of various types, which had been carried out over a period

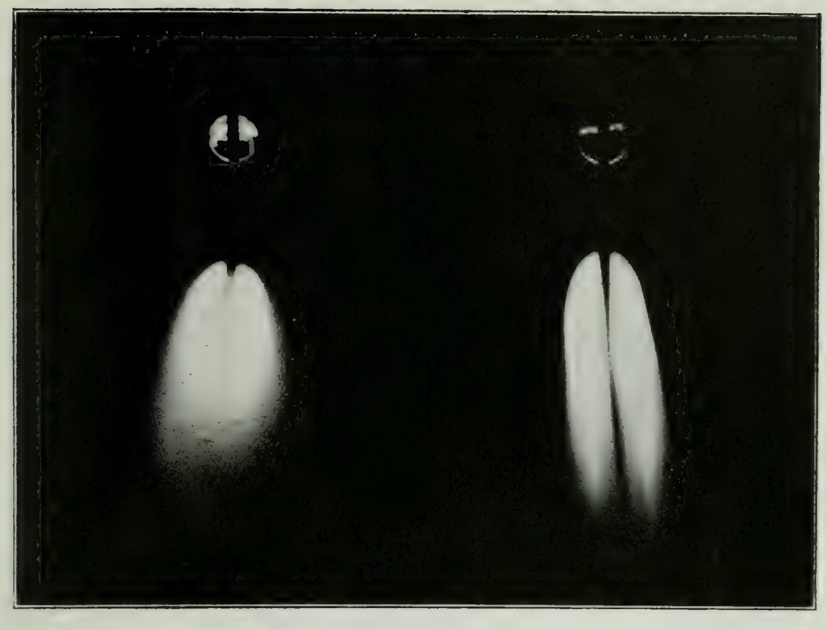

FIG. 1.—Diffusion—Similar lamps equipped with similar types of reflectors. That on right polished surface, that on left depolished surface. Note softening of shadows from depolished surface.

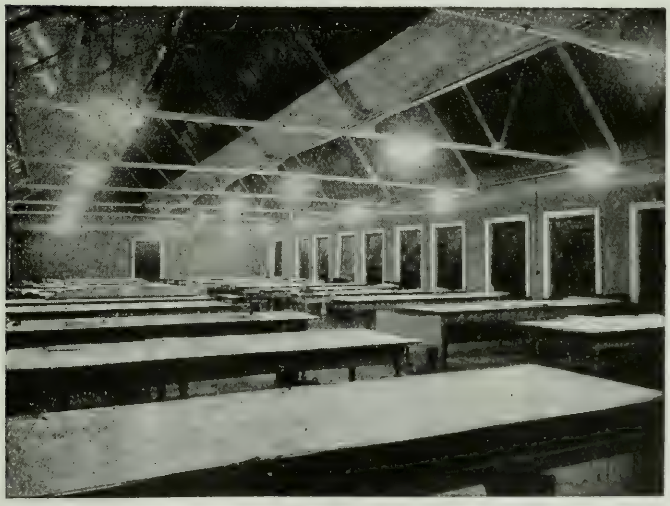

FIG. 2.—Illumination of a modern drawing office with semi-indirect units and half-watt lamps, with a view to avoiding inconvenient shadows.

Mr. H. C. Wheat.

covering several years, and which, having the requisite diffusion, were entirely sufficient for the purposes for which they were designed. The slides cover examples of offices employing indirect and semi-indirect lighting, where the conditions were particularly severe, and a variety of engineering and textile works with direct lighting.

One slide was shown illustrating a portion of a large boot factory, which was equipped solely with local lighting giving a very brilliant light on the work, and practically none on the floor. Such conditions would be much improved if the recommendations of the Committee were enforced, and sufficient general lighting provided to secure the necessary minimum illumination on the floor, thereby reducing very strong contrasts which existed.

As regards the lighting of sewing-machine benches by general illumination, the speaker stated that his experience showed that this could not be successfully accomplished on account of the overhead obstruction from the machines themselves. He showed a slide of an installation equipped with local lights, and in which a sufficient general illumination was provided by the light reflected from the benches.

Some slides were also shown illustrating the fact that with properly equipped lamps these could be raised far above the line of vision, and with considerable gain in the shadow effect.

Before concluding, the speaker said he would ask if the recommendations of the Committee regarding minimum illumination on the floor were to be taken literally, *i.e.*, the darkest spot that could be found, or simply a fair average? The exact interpretation would make a very great deal of difference.

Mr. C. C. PATERSON (National Physical Laboratory) endorsed all that Mr. Dow had said, and emphasised one or two of the points mentioned. With regard to what it was stated was done in American Factories in whitening floors, &c., he would like to know how the whitening of floors was carried out. He remembered going over one factory where the floor was tiled with light coloured tiles, and it was extraordinary what a small illumination sufficed to make it look relatively brilliant. Floors would do with appreciably less than the 0.25 ft. candle recommended in the Committee's report if they were generally lighter coloured. Floors in many factories, however, were of wood blocks or planks which got very dirty, and it would be nice to know a satisfactory way in which these could be kept clean in the interests of appearance as well as safety.

On the question of diversity factor, he thought that generally a relatively low degree of even illumination was preferable to high illumination but with a big diversity factor. The more one saw of factory lighting the more one was impressed that it was not really necessary to have long schedules of illumination values different for each class of work. Work could be divided very roughly into three or four groups, as suggested in the paper, but there was one class which should be considered separately which was not mentioned in the table shown by Mr. Dow, and that was textile work. He did not mean weaving but the making up of ordinary materials and fabrics. Such classes of work require separate consideration because 3.5 ft. candles would not be sufficient for dark materials.

With regard to indirect lighting, it would be advisable, as suggested, to have a little more data to enable us to know what the diversity factor was and what the distribution of the light was in typical cases, worked out to the same degree of accuracy as had been done with direct lighting. Indirect light to him was in many respects an ideal system. Every system had certain disadvantages, but he could not conceive a better system for very many classes of work. There was only one instance in the report where indirect lighting seemed to fail, and that was where the character of the work depended upon producing shadows or graduation of shade as in a self-toned fabric where the different strands were only distinguishable from each other by this means.

Mr. A. CUNNINGTON (L. & S. W. Railway Co.) said that some work he had done approximated closely to factory work, namely, the lighting of large covered goods warehouses. The floors of these

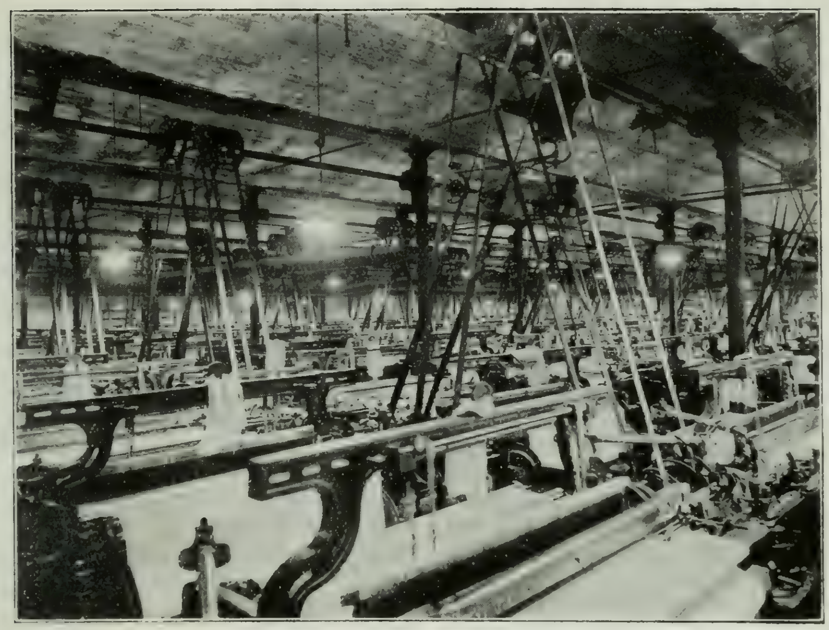

FIG. 3.—Weaving shed. General illumination.

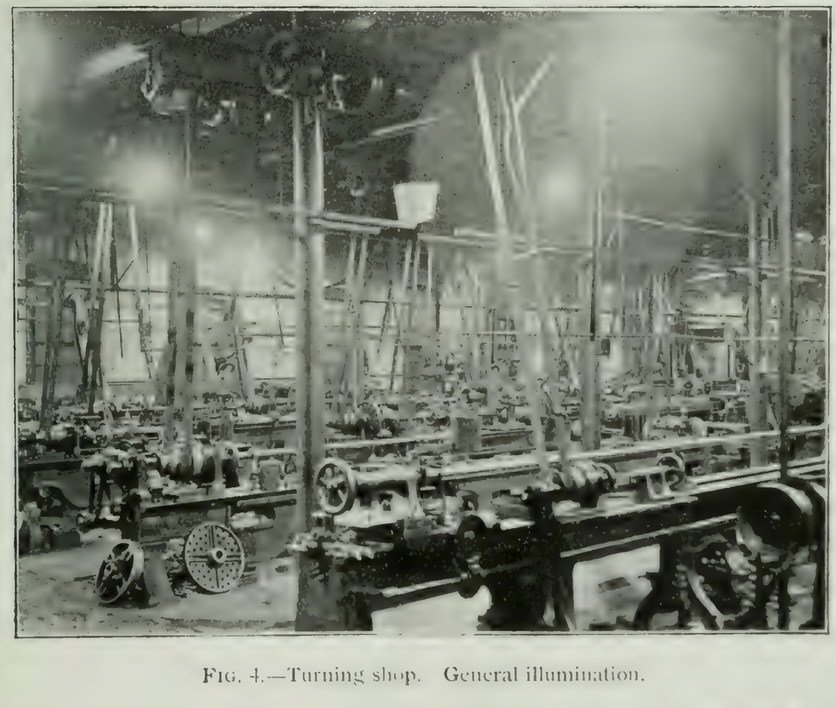

FIG. 4.—Turning shop. General illumination.

Mr. H. C. Wheat.

warehouses were, in regard to lighting requirements, very similar in condition to the floor of a factory in that they were largely occupied by obstacles, such as packing cases, etc., lying about somewhat promiscuously, but with certain passageways in between. He had collected a few figures of a number of tests he had carried out at different goods warehouses, which showed there was no difficulty in arriving at the figure of 0.25 ft.-candles as a minimum for the floor. This figure, however, represented what he called the general minimum; in other words he had not gone into the very darkest corner of the room in order to take the reading, but had measured the illumination midway between lamps. Taking the case of a long row of gas lamps down a narrow platform, the figure of 0.25 ft.-candles as a minimum was often exceeded. The actual values between lamps varied from 0.2 to 0.4 ft.-candles. He might mention one other particular case of a very large shed, in which arc lamps were used, where the maximum was very high, and the minimum fell rather low, the actual figures being 5.0 and 0.15 ft.-candles respectively. By substituting half-watt lamps for the arc lamps, the maximum was reduced to 1.0 ft.-candles, and the minimum increased to 0.25 ft.-candles, and the lighting was consequently very much better. This served to emphasise a point which he considered very important, viz., the avoidance of excessive contrast. When high candle power units were used, great care should be taken in calculating height and spacing, so that there was not too great a diversity between the maximum and minimum. He had many times established the fact that if greater uniformity were aimed at, a lesser maximum intensity would suffice.

The condition and colour of the floor had, of course, a very marked influence on the illumination required for seeing objects; therefore the minimum fixed should be such as would clearly show up an object, even when there was very slight contrast between it and the floor. It had been suggested to him that if it were possible to obtain a uniform illumination of 0.25 ft.-candle throughout, the appearance would be that the floor was inadequately lighted, and obstacles would not be clearly visible. As a matter of fact he had discovered an area of about 30 ft. square, in which the illumination was 0.25 ft.-candle practically all over, and he could assure them that, although the floor was dark in colour, there was no difficulty in distinguishing objects by this light. He himself confessed to being surprised to find what a bright illumination 0.25 ft.-candle really was.

With regard to whitening steps as a safeguard, there was one difficulty that he might refer to. The point was that as soon as a step was whitened, the person doing so accepted responsibility for keeping it white, This was the case with railway platforms, and it saddled railway companies with that responsibility. The trouble was that a whitened step quickly became dirty, and if then somebody fell down, the person responsible for whitening it in the first place was likely to be held responsible for the accident.

Mr. L. GASTER said Vol. III. of the Home Office Report was a most useful production, containing a unique survey of existing lighting conditions in the classes of factories visited. This volume would be most serviceable to lighting engineers and the thanks of the Society were due to the Home Office for undertaking this laborious piece of work.

He thought all would agree that Mr. Dow had collected an excellent series of practical examples of installations, showing that the requirements of the Report could be easily met by modern methods. Mr. Dow had dealt in an entirely impartial manner with the information kindly afforded by various members relating to gas and electric installations.

There were many points of interest in the paper. He would like to refer particularly to one of these points—the matter of shadows. It was not enough merely to provide a certain amount of illumination; it was also necessary to arrange the lamps and reflectors so as to avoid inconvenient shadows which had often confusing results. For example a deep shadow on the floor might mask an obstacle, leading an operator to stumble, or to mistake the position of an aperture in the floor; conversely deep shadows sometimes led people to think there were obstructions on the floor when they did not exist.

As regards the interpretation of the minimum values of illumination, he felt sure that reasonable latitude would be allowed and that there was no intention in the Report of causing any hardship. He agreed with Mr. Paterson's remarks regarding the sympathetic attitude of the authorities in these matters.

Mr. F. W. **Willcox** (British Thomson-Houston Co.): With regard to the light-coloured floors referred to by Mr. Paterson, it will be found, I think, that when buildings are properly lighted the tendency will be to keep the floors clean and they will therefore be much lighter particularly if the wood is of a light natural colour) than under the general conditions where factories and rooms are poorly lighted. Many of the floors in American factories are made of a light coloured or white wood and can be scoured and kept quite clean. In other cases floors are covered with light floor coverings such as linoleum, etc.

For illumination in general I think we should keep in mind an ideal, and, I think, the ideal result in illumination should be an unconscious one. It is a sign of health and efficiency when results are worked out unconsciously. A man in perfect health is not conscious of his stomach or other organs. Good lighting should subscribe to the same conditions and like day-light should be so distributed and arranged as to secure the results desired unobtrusively.

There is a further point to be borne in mind in connection with illumination and that is there is something more in illumination than it is possible to express in mere physical values such as candle power in foot-candles. As an expression of illumination results such physical values are incomplete as there are physiological and psychological effects which need to be considered. In illumination we not only have to deal with the source of light and its accessories such as the reflector or glass globe, but with the object to be illuminated upon which the light falls, and finally, the most important of all, the eye of the observer which must receive the light reflected from the object. It is the eye which is affected by the physiologcal and psychological causes and there would seem to be special conditions of illumination in certain kinds of lighting such as indirect lighting which enables the eye to function better under one form of light than with another form giving the same physical value of illumination.

It is possible, for example, to increase the total amount of light in a room to the serious detriment of the illuminating effect because a brilliant glaring light in a room causes the pupil of the eye to contract and with a greater amount of light, less actually gets into the eye; therefore the illuminating effect secured is poorer than it would have been with a lesser amount of light properly diffused or distributed. These conditions emphasise particularly Mr. Wheat's remarks concerning the importance of diffusion. The excellent diffusion obtained by indirect lighting is thus one of the greatest sources of its satisfaction to the user. With the perfect diffusion given by indirect lighting the pupil of the eye opens more freely, and therefore tends to receive more light; the observer can thus see to better advantage than where the light is poorly diffused and the pupil of the eye contracts through glare or excessive brilliancy.

As regards the question of local lighting versus general lighting, it is an inevitable result in the advance in efficiency of illuminants that there should be a progressive tendency towards general lighting in place of local lighting. The steps can readily be traced from the early candle, which required the worker to sit with the book or work close to the flame in order to see perfectly; to the table oil lamp, where the reader or worker could move the lamp some distance away; to the early gas lamp which could be placed some distance above the reader or worker; to the electric lamps which could be placed still higher; and so on to the latest lamps which can be placed on the ceiling of interiors and with proper equipment of diffusing globes, give sufficient and economical illumination for the average working condition.

There are many cases of work, such as the letter sorting referred to, where local lighting is desirable, but in all such cases it would be supplemented by general illumination as well. Such general illumination need not be of the same degree as that where local lighting is employed, but it should be sufficient to avoid too great a contrast between the light cast by the local lamp and the light of the general surroundings.

Oculists maintain that the eye suffers serious impairment when it works in a room that is absolutely dark generally with strong local illumination on book or work. The reason given for this is that the pupil of the eye is expanded in conformity with the general dark surroundings and when it views the locally illuminated spots the pupil usually suffers by taking in too much light as well as by the changes it undergoes in trying to adapt itself to the two widely separate degrees of illumination. Therefore, where local and general illumination are employed care should be taken to avoid too great a contrast between the two.

Mr. O. E. **Grigsby** expressed his aproval of the rough division of manufacturing operations according to the amount of illumination required, as indicated in the table quoted from Mr. Dow from the American Code. It seemed desirable that factory inspectors should have such classifications made for their guidance. No doubt this question of values for Industrial Operations would receive the attention of the Committee in future work. He pointed out that the value of 0.25 given in the American Code is for Storage, Stairways and the like, while the value specified by the Committee for these areas is only 0.1, and that for working areas a much higher value than the 0.25 was apparently suggested in the Code.

The discussion showed clearly the alteration in the conditions in factories brought about by improved lamps and lighting appliances. He observed that in most of the factories visited by the Committee old types of lamps were used, so with newer types the minimum specifications could be materially exceeded and the illumination raised to a higher value without the cost being burdensome.

The effect of the walls and ceiling in increasing the illumination of the working plane was an important matter. There was a well known table which was used in America for calculating this increase. According to this table with very dark walls and ceilings an increase of 15 per cent. might be allowed for; with walls and ceilings of the medium tint an increase of 40 per cent.; with very light ceilings but dark walls 30 per cent.; with both walls and ceiling light, as much as 80 per cent.

Mrs. **Cloudesley Brereton** said there were two points she would comment upon in relation to this matter which Mr. Dow had raised. The first was with regard to physiological conditions. She would like to remind some of those present who might have heard Sir John Cockburn's speech at the time of the National Gas Exhibition, when he spoke of the physiological effect of ample illumination and gave his experience of the stimulating effect of good lighting when he was fatigued and worn out at night. He said that under those conditions he sometimes turned on every light in his library, and the result was as good as a bottle of champagne. This had a distinct bearing on output in factories, because the experience of employees was that the effect of working in a large amount of light equivalent almost to sunshine, had such an effect upon the spirits of the workers that physiologically girls, at any rate, were in better health. That was a fact to be brought home to employers of labour.

The particular case the Chairman mentioned about the sorters in Post Offices was also an important one, and as another speaker had said, the contrast between the light on the working plane and the general lighting must not be too great. This contrast was now to be seen very much in the lighting of the streets, and with motor cars especially, but taking the lighting of factories generally, good lighting had a very important physiological and psychological effect upon the workers. If backward factory managers could be brought to comply with the recommendations of the Home Office, they would certainly find they would obtain increased output, which was a thing to be considered very much in the near future.

The second point was the question so

often brought before the Society, and that was the necessity for the close co-operation between builders, decorators and illuminating engineers. The figures given by the last speaker were significant in this connection, as they showed it was possible to get an increase of 80 per cent. illumination in comparison with zero according to the scheme of decoration adopted. It therefore behoved the factory manager and the factory owner to consider his decoration as part of his illumination problem. As one interested in public health matters she hoped this co-operation would soon be an accomplished fact, and would bring about that state of cleanliness and general health in factories which was, until lately, hardly dreamed of except by incurable optimists.

Mr. C. H. PITMAN spoke on the question of glare and the necessity of keeping down the intrinsic brilliancy of lighting units.

One of the most satisfactory forms of lighting in this connection, he said, was the Moore tube.

For the same reason ideally indirect lighting would be most satisfactory from a lighting point of view in a factory where general lighting is installed, but there would be a difficulty in keeping the reflectors and local surroundings clean, consequently loss of light would be enormous. making it impracticable.

He therefore thought it would be admitted that the semi-indirect system would be the nearest practicable approach to the indirect method of lighting, as it did not suffer from the great depreciation in lighting value, and with sufficient care in design it was quite possible to manufacture a unit which will not collect dirt, &c., unduly.

Mr. Dow had laid particular emphasis on the fact that all lights should be out of the direct eye-line unless adequately shaded—meaning that the covering reflector should be brought round the light surface to hide the lamp from the eye when looking across the workshop. But it is quite possible to design a semi-indirect fitting to be hung at medium height and having a large diffusing surface, thus entirely avoiding glare. This at the same time is a big step in the direction of breaking up shadows, and the greater the area of the reflecting surface the better this is accomplished.

Mr. E. STROUD (*communicated*):—In the discussion on the Home Office Report a great deal of attention has been devoted to the proposed minimum illumination of 0.25 ft.-candles. The provision of such a minimum is good, but at the same time I would like to point out that there is another factor of equal importance which requires to be specified, and that is the *ratio of contrast in illumination.* It is clear that should there be in certain sections of a factory a very intense illumination, a minimum of 0.25 ft.-candles (or even higher) would not suffice for safety. I notice that among the examples mentioned by Mr. Dow was a certain factory, lighted by carbon filament lamps, where the illumination on the work was 1 foot-candle and the minimum value in the working area 0.2 ft.-candles. These are admittedly low values, and the fact that they were apparently considered sufficient seems to be due to the ratio of maximum to minimum illumination being small, and undue contrast thus avoided.

Mr. Dow also raises the question whether one can predict the actual illumination that will result from a given arrangement of lighting units. This is quite practicable in the case of direct lighting if one uses reflectors whose distribution curve is known, and the only two variable factors to be taken into account are the reflection from surroundings, and the actual candle power of the lamps used.

The increase in illumination due to reflected light from surroundings can be ascertained for a given class of reflectors, and has been published for their reflectors by the Holophane Co. for many years. These figures, which were quoted in a the course of the discussion, must not be taken as general for any type of reflector. For example, in the majority of industrial installations opaque reflectors are used and it is therefore obvious that no reflection from ceilings and extremely little reflection from walls, will be obtained.

The prediction of results by indirect lighting seems to be a rather harder proposition, and I should doubt if it is possible to state beforehand with any degree of accuracy the results attained with this form of lighting. Mr. Dow mentioned one case where much less illumination was expected than was actually obtained, and I myself have taken out several series of tests in which predicted results have not been realised, results varying in both directions.

The other point which naturally affects the results in practice is the light given from the lamps used with reflectors. If the actual candle power of a lamp differs widely from its rated value the expectations of a lighting engineer will naturally not be complied with. This illustrates the need for co-operation between makers of lamps and reflectors.

As regards the suggestion made by Mr. Willcox that less illumination is required for a given process by indirect than by direct lighting, this, of course, is a highly debatable matter, on which further research is needed.

Mr. G. Campbell (*communicated*) :—Mr. Dow's paper appeals to me as an excellent Addenda to the discussion on Mr. Gaster's Notes before the Society in November last, and there is no doubt will form a very good lead for more practical information of this kind.

In referring to the many variations in the actual illumination applied in different factories for similar processes, the need for some recognised standards of illumination on the working plane for such and other processes is emphasised. Whether or no the average of the values recorded in the tables mentioned in Vol. III. of the Report would produce the correct figures is a matter for investigation—it may be found that the large majority of instances are not satisfactory from the point of view of " adequate " illumination—one cannot help feeling, as suggested by Mr. Dow, that the recommendations in the American Code might very well form a basis for these standards, particularly if the averages of the tabulated values to some reasonable extent coincide.

Too little has been said in considering these matters regarding the large decrease in efficiency due to the collection of dust and dirt on light units in use. Mr. Dow made a reference to this point. A regular cleaning should be carried out, if necessary by compulsion, as this alone would improve the illumination of thousands of factories and workshops, while old electric lamps and worn-out gas mantles should at the same time be replaced. An allowance for this rapid deterioration should be made in designing installations based on photometric results from new and unused units.

The avoidance of glare increases the ability of the operatives to see, and it is pleasing to note the strong references Mr. Dow makes on the subject. It would be intersting for some member to submit to the Society in connection with industrial and other lighting some data on the relative increase in the " ability to see " due to the shading of bright lights in the range of vision.

It may be mentioned in connection with inconvenient shadows that where a reasonably economical scheme of general illumination will not dispense with serious shadows it is a sure thing that local illumination is an absolute necessity—of course if light units are placed in the wrong position it is obvious annoying shadows result.

In conclusion, I am sorry that Mr. Dow did not give us his views on lateral or side lighting—one of the most difficult problems in industrial lighting. To get satisfactory side lighting and at the same time comply with requirement (3) regarding shading of lamps, requires very special attention unless of course there is plenty of headroom to place the lights high above the vertical plane of illumination.

I am sure the Society is indebted to Mr. Dow for his paper.

Mr. J. S. Dow (in reply) : I must express my thanks for the kind way in which my introductory remarks have been received ; I am glad to think that the discussion has been useful in clearing up some of the points discussed at our meeting last November.

Much has been said on the debatable question whether general or local illumination is best for offices ; Mr. Wheat showed some interesting examples of the former method. I think, however, as Mr. Goodenough pointed out, that much depends on the concentration of attention required in the work ; for simple and more or less habitual processes general illumination would doubtless suffice.

Mr. Wheat suggested that more emphasis should be placed on diffusion. I thought I made this clear when alluding to the importance of light interiors, and I entirely agree that in most industrial processes light striking the objects from many different directions is necessary. These conditions are best secured by utilising the reflecting power of light walls and ceilings ; and, as Mr. Paterson remarked, for many kinds of work indirect and semi-indirect systems have an advantage in this respect. I also agree with Mr. Wheat that a measurement of the horizontal illumination is not everything necessary, and that one must judge an installation also by consideration of other factors, such as diffusion, absence of glare, etc. But, as was long ago shown by Mr. Trotter, a measurement of the horizontal illumination is much the most convenient single measurement that could be prescribed.

Mr. Campbell referred to the rather difficult cases where a side-illumination is needed, and yet glare must be avoided. As mentioned above, this is often merely a question of diffusion, and reflection from light surroundings is helpful. When a strong *uni-directional* light is needed for some special purpose one can usually avoid glare by employing well-shaded local lights.

As regards the whitening of floors, a concrete floor often reflects a very useful amount of light, and, as Mr. Willcox mentioned, light wood floors can be kept clean if the processes taking place do not give rise to much dirt or dust. In very grimy workshops, foundries for example, much reflection from the floor can hardly be expected.

Several speakers, Mr. Cunnington, Mrs. Cloudesley Brereton and Mr. Stroud, referred to the effect of contrast. I quite agree that severe contrasts in illumination may render a higher illumination necessary, as was shown in a valuable paper recently read by Dr. Nutting, before the American Convention. It is, however, somewhat difficult to fix a limit, and provided "a reasonable degree of uniformity," as prescribed in the Report, is provided, the contrast should not be excessive ; the effects of such severe contrasts are, however, usually less trying than the glare from exposed sources of light.

Mr. Paterson was inclined to doubt whether, even in those cases where it is desired to illuminate the entire working area evenly, the variation in illumination would not exceed 25 per cent. I quite agree that this figure would be exceeded in most installations, nor is such strict uniformity absolutely necessary. I mentioned this figure merely as an indication of the conditions that might be secured when scientifically designed reflectors are used and spacing rules rigidly adhered to, and where no local conditions interfered with the carrying out of the installation on the theoretically approved methods.

Mr. Grigsby gave some figures for calculating the effect of light surroundings. I think that we must agree with Mr. Stroud that such tables are not a safe guide unless the system of lighting to which they refer is also indicated. So much depends on the amount of light directed downwards. Another most important factor is the size of a room. In a small room reflection from the walls, which are quite close to the object viewed may have a very considerable effect ; but in a large hall with lofty ceiling the illuminated surfaces are so distant from the centre of the room that they render very little help. We then approach the conditions found in exterior illumination.

Mr. Grigsby, in referring to the 0·25 minimum, pointed out that the figures quoted in the American Code were apparently somewhat higher. I think that if the Report is properly interpreted the illumination necessary in the interests of safety will be found to be very similar to that specified in the Code. It must be remembered, too, that the three higher classes of illumination stated in the Code are intended to suffice for the *work done* as well as being necessary for safety. There seems to be a consensus of opinion that the specification of the amount of illumination necessary for industrial processes might be simplified by division into several main groups, as indicated in the American Code.

Several other speakers inquired as to the exact interpretation of the 0·25 minimum (*e.g.*, as to whether this would refer to small areas of the floor in partial shadow, etc.). It is really not desirable to make such a specification too rigid, and I can only echo the remarks of Mr. Gaster and Mr. Paterson in expressing the belief that such standards would not be interpreted harshly, and that in cases where a deviation from the standard obviously caused no detriment to workers or employers, reasonable latitude would be allowed.

ERRATA.

We regret that through a clerical error an abstract (4 cols.) of the Home Office Report on Factory Lighting in the *Electrical Review* for September 17th was inadvertently omitted in the table of Press comments published in THE ILLUMINATING ENGINEER for December, 1915, p. 490.

We are glad to record this additional instance of the attention given in the technical press to this important Report.

In THE ILLUMINATING ENGINEER (January, 1916) the illustrations referred to as Figs. 2 and 3 in the text, pp. 14—15, were accidentally interchanged.

The matter referring to Fig. 2 should apply to Fig. 3 and *vice versa*.

FIRST REPORT
OF THE
Departmental Committee
ON
LIGHTING IN
FACTORIES
AND
WORKSHOPS.

Chairman :
DR. R. T. GLAZEBROOK, C.B.

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THE ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

Mid-Winter Convention to celebrate the Decennial of the Existence of the Society.

We note with interest that a special Convention of the American Illuminating Engineering Society was held in New York, on February 10th—11th, this being the celebration of the decennial of the Society's existence. A number of interesting papers were read, reviewing past progress and making suggestions for the future.

A cabled message of good wishes was sent to the Illuminating Engineering Society in London by the President (Dr. Charles P. Steinmetz) as follows :—

"The Illuminating Engineering Society,
32, Victoria Street,
London, S.W.

The Illuminating Engineering Society in the United States, upon the celebration of the decennial of its organisation, extends to the Illuminating Engineering Society greetings and best wishes."

This message was responded to as follows :—

"The Illuminating Engineering Society,
239, West 39th Street,
New York.

Society heartily reciprocates greetings and good wishes."

All members will join in wishing our friends in the United States continued prosperity and success in the good work they are accomplishing.

CORRESPONDENCE.

THE EFFECT OF SHAPE OF FILAMENT ON DISTRIBUTION OF LIGHT FROM STANDARD TYPES OF REFLECTORS.

Feb. 8th, 1916.

To the Editor of the ILLUMINATING ENGINEER.

DEAR SIR,

With further reference to Professor Morris's paper on "Recent Developments in Electrical Incandescent Lamps in Relation to Illuminating Engineering," and published in the January issue of the journal, I should be greatly obliged if you would insert in the February issue the enclosed three sets of polar distribution curves which have an important bearing on Professor Morris's remarks.

These sets of curves shew the comparison of the distributions obtained by using Holophane Extensive, Intensive, and Focussing Reflectors, with the ordinary straight filament lamps and with the bunched filament similar to that employed in the gas filled type.

The bare lamp curves are plotted for comparison purposes, the horizontal CP to equal 100.

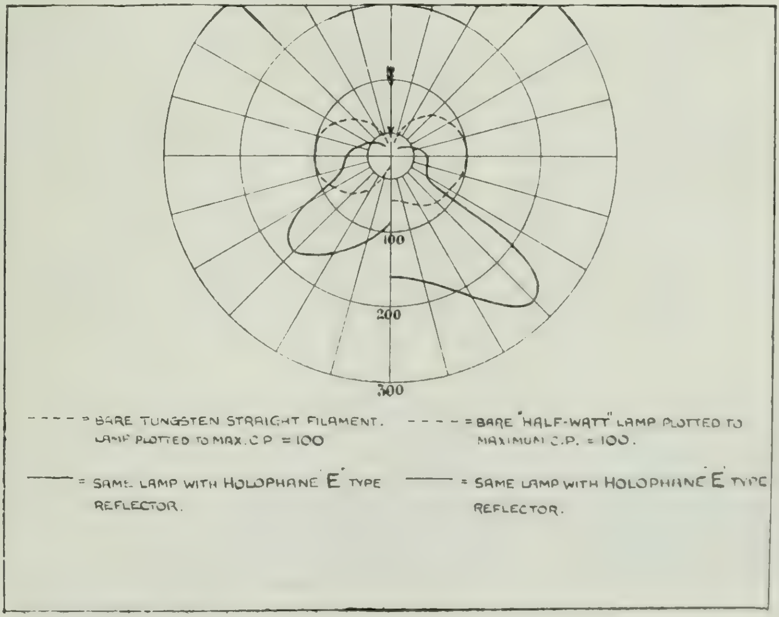
It will be seen that by using the bunched filament the characteristic curves are not altered, but are accentuated to a marked degree, the E and I curves giving 50% more light at 45 degrees and 30 degrees respectively, and in the F type a considerable increase in the downward direction.

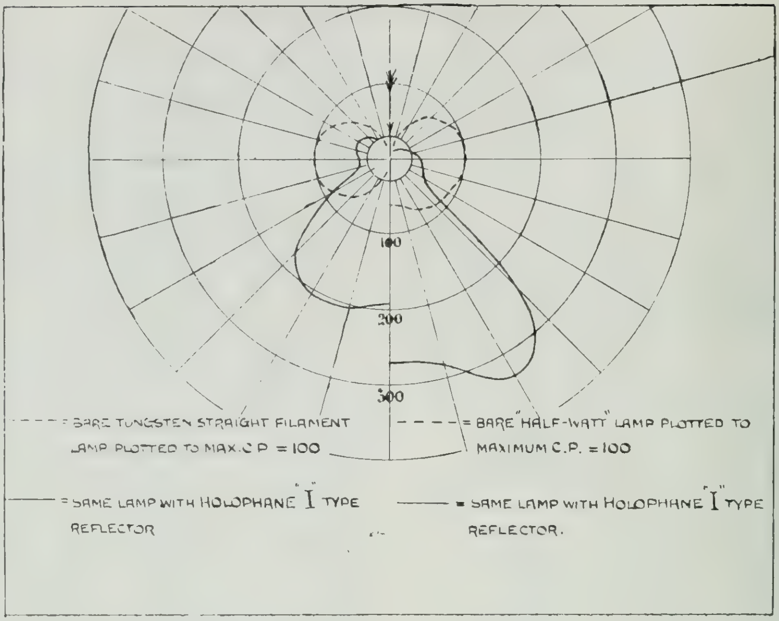
These results are proved in the figures given by Professor Morris for the lighting of the drawing office of the East London College, where by using spiral-form filaments instead of straight type, and using the same Holophane Reflectors he reduces his consumption by 33% and increases his Horizontal Illumination by 33%—an important saving.

In Professor Morris's remarks he suggests that this increase in illumination is due to the filament being so formed as to throw more light in a downward direction. But this increase will be found to be due, not to the mere fact of the filament being so formed, but to the greater efficiency of the Reflector itself in these circumstances. Prismatic Reflection is such that the smaller the source of light (that is, the nearer we approach the point source) the greater will be the efficiency of reflection, but also it must be borne in mind that greater care is necessary in placing the source in its proper focus. It is in this respect that lamps must be designed so that a greater percentage of the light flux above the 60 degree zone may be collected by the Reflector and distributed where it is needed.

Yours faithfully,

E. STROUD.

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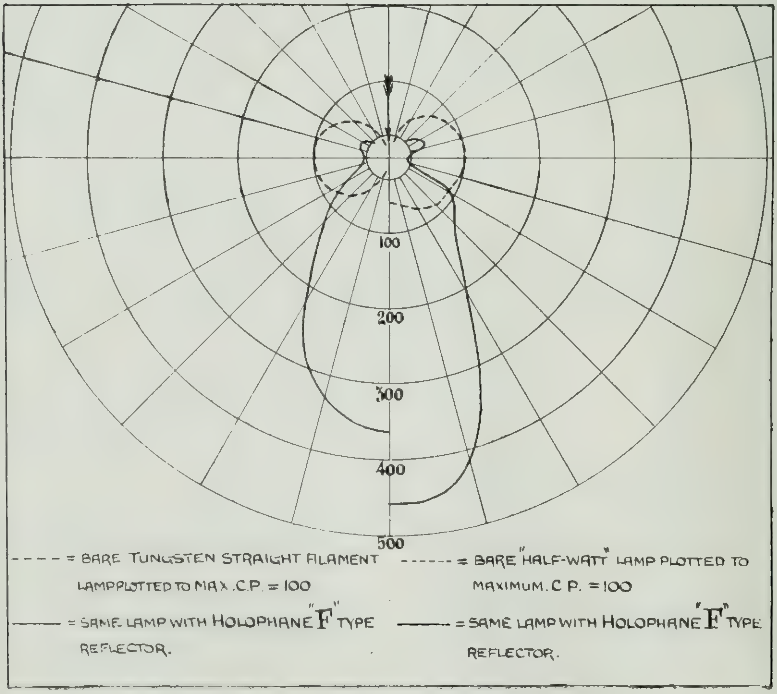
——— = SAME LAMP WITH HOLOPHANE "I" TYPE REFLECTOR.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——— = SAME LAMP WITH HOLOPHANE "F" TYPE REFLECTOR.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

B.T.H. ELECTRIC INCANDESCENT LAMPS.

The latest list of incandescent lamps issued by the **British Thomson Houston Co., Ltd.,** is undoubtedly one of the most complete we have received for some time. Lamps ranging from the smallest battery variety up to the high candlepower half-watt types are listed; the dimensions of the bulbs are stated in each case and a block is given showing the general shape of the filament.

We notice also that an attempt is made to include in the list some suggestions regarding the use of the lamps, and that photos of installations and of a few typical fittings are included. The list very properly commences by an explanation of the difference between mean horizontal and mean spherical candlepower. It is remarked :—

> "The efficiency of lamps is usually expressed in terms of its mean *Horizontal* candlepower, *i.e.*, watts per mean *Horizontal* candlepower. It should be stated, however, that this basis for comparison is correct only for lamps having the same shaped filaments or filaments giving the same ratio of mean horizontal to mean spherical candlepower. The spherical efficiency or watts per Mean Spherical Candlepower is a correct basis of comparison. . . ."

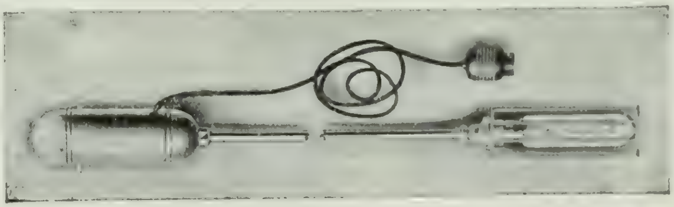
Formulæ are accordingly given, enabling the two quantities to be related for certain types of lamps. The proposal is also made that lamps are more properly rated in "lumens per watt."

There are two suggestions we would like to make regarding a future edition of this list; *firstly*, that polar curves of a few typical filaments, both for gas-filled and vacuum lamps should be given; and, side by side with them, the corresponding curves for the same lamps in typical reflectors, such as are used in practical lighting calculations; *secondly* that in the tables of costs the expense of lamps and current should be separated so that consumers can ascertain when it is most economical to use ordinary or half-watt lamps.

SHELL-INSPECTING HAND LAMPS.

Besides general illumination in a factory, it is often needful to provide special lighting at some particular point. An instance is afforded by deep borings, such, for example, as occur in shell-work, where a special hand-lamp, which can be passed into the interior, is useful. The illustration shows a lamp of this kind supplied by the B.T.H. If necessary these small lamps can be worked from accumulators or dry cells

A useful B.T.H. Lamp for shell inspecting.



REVIEWS OF BOOKS.

Standard Cloths, Structure and Manufacture. By Roberts Beaumont, M.Sc., M.I.Mech.E. (*Scott Greenwood and Son, London,* 1916) *;* 325 *pages,* 16 *plates,* 150 *illustrations.*)

At the present time, when all are impressed by the need for studying and maintaining the great national industries, this volume deserves special notice. The author, as Professor of Textile Industries at Leeds University, has had special opportunities of studying the technical side of cloth manufacture, and no little expert knowledge is necessary to appreciate the methods of producing the various qualities of fabric and blends of colours. In the first two chapters there is a full account of the nature of fabrics, illustrated by useful microscopic illustrations. Then we have a synopsis of cloths and an account of special fabrics light in weight and structure, medium weight worsteds, overcoating materials, felt, etc.

Of special interest to us is the account of the methods of producing standard colours, such as tartans, khaki and French grey. To many people it will come as a surprise to find that khaki, as used for army work, is a blend of quite a number of different shades. These points are illustrated by several excellent colour plates, and the numerous diagrams and illustrations throughout the volume form a most useful feature. We should have liked to have heard a little more regarding the methods of selecting standard colours and the extent to which such processes are affected by variations in the colour of light used to illuminate the material; but possibly this point is covered in one of the author's other numerous works.

Those interested in standard practice in specifying textile materials should find this work of considerable interest.

Practical Lessons of the War. (*The Engineer Office,* 33, *Norfolk Street, London, W.C. Price 2d.*)

Under the above title *The Engineer* issues a series of six articles which appeared in that journal during 1915. The object is to point out clearly (1) the effect of the war on British Industries; (2) the manner in which our industries are likely to be situated after the war; (3) a means of over-coming the various anticipated obstacles; (4) the necessity of concerted action between Great Britain and her Allies; and (5) solutions of this difficult problem.

The articles make interesting reading and contain many interesting suggestions.

The Practical Electrician's Pocket Book. Edited by H. T. Crewe. (*S. Rentell and Co., London,* 1916. 474 *pages.*)

This little red volume appears once more As usual it is full of condensed information and we note that several new chapters have been included dealing with such matters as electric vehicles, drills, blowers and lifting magnets, mining telephones and shaft signals, etc.

In the brief section on lighting we notice what seems a reasonable classification as regards the illumination required for various purposes; it might, however, be well to distinguish more clearly between the illumination required for various processes, and the illumination needful as a measure of safety.

There is also a page containing polar curves of typical electric lamps, a brief account of modern electric illuminants, and a section on photometry.

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ALL PIPED FOR GAS.

We are indebted to *The Gas Industry* (New York) for the accompanying photograph showing the great new Woolworth building in New York City, the entire structure of which is piped for gas.

The immense height of the building and the array of brightly-lit windows must make it a prominent object visible from a considerable distance, so that it forms an excellent advertisement of gas-lighting on a big scale.

GAS AND MUNITIONS OF WAR.

In a recent lantern lecture delivered before the Derby Society of Engineers, Mr. H. M. Thornton, M.Inst.Mech.E., in describing the manifold uses to which gas is put in the manufacture of munitions of war, gave a few interesting facts in regard to the famous 75 mm. shells. The furnace used in French and Belgian factories for "heading" these shells, he said, is very strongly made, and the top part, which looks like a turret, revolves upon ball-bearings, the speed being completely under control. The heating capacity of the machine, for which gas and air-blast are used, is 120 shells per hour. A single powerful burner plays on the bottom of the furnace from the top, and the interior is so arranged that the end of the shell only is heated with that accuracy which is so essential. It is interesting to note that this particular furnace is built in this country for our Allies.

Among other illustrations of the special uses of gas in munition-making at the present time, Mr. H. M Thornton mentioned the thermo-treatment of metals as exemplified in the various stages of shell-making, the construction of aeroplanes and motor-cars and the manufacture of tools of various kinds.

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For Sale, 14 handsome English cut and engraved Glass Globes for electric light, suitable for large hall. Height, 12 in., circumference 25 in.—Apply Box 20, c/o The Illuminating Engineer, 32, Victoria Street, London, S.W.

The large new Woolworth building in New York, lighted throughout by gas.

MODERN ILLUMINATION AS APPLIED TO GAS LIGHTING.

A lecture on the above subject was given by Mr. E. Stroud at a recent meeting of the Scottish Junior Gas Association. Mr. Stroud referred to the recent Home Office Report on Lighting in Factories and Workshops, and explained how by using standard types of Holophane reflectors an even illumination of a given intensity could be obtained. Special stress was laid on the avoidance of undue contrasts in brightness.

A discussion took place in which Mr. Colquhoon (Glasgow), Mr. J. M'Ghie (Glasgow), and Mr. J. Wislon (Falkirk) took part. The President, in winding up the discussion, emphasised the importance of the scientific study of illumination to gas engineers.

The
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Edited by
LEON GASTER

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EDITORIAL.

Industrial Research and the Scientific and Technical Press.

An important discussion on " The Sphere of the Scientific and Technical Press in relation to Technical Education and Industrial Research " took place at the last meeting of the Circle of Scientific, Technical and Trade Journalists on March 14th, at the Hall of the Institute of Journalists. Introductory addresses were delivered by Dr. W. Garnett, late Educational Advisor to the L.C.C., and Mr. A. P. M. Fleming, of the British Westinghouse Electrical Manufacturing Co., who has made a special study of Industrial Research.

The object of the meeting was to consider in what ways the technical and scientific press can best extend its services in bringing the benefits of technical education and industrial research more prominently before the notice of manufacturers and the public. Before considering this matter it was thought desirable to obtain a general survey of the present position, and the addresses of Dr. Garnett and Mr. Fleming (which we contemplate publishing in full, together with the valuable ensuing discussion, in a coming number of this journal) furnish a clear exposition of the subject.

The imperative necessity of organising the scientific and technical resources of the country in a more scientific manner is now widely recognised. Among the various steps taken in this direction one of the most important is undoubtedly the creation of a Committee of the Privy Council charged with the duty of developing Industrial Research, and it is significant that the grant allotted to its Advisory Council for research during the present year, although still far from adequate, has been substantially increased. This is rightly recognised as a direction in which money well spent now will be amply repaid in the future.

The promotion of unity of effort on the part of the various Associations and Societies interested in applied science is most important. We are glad to see that the Royal Society is considering this matter, and that at a recent conference it was decided to form a Board to advise the Government on any branch of scientific enquiry that may be brought before it.

In the lighting industry we believe that there are many problems which would well repay further investigation, and this matter is to be dealt with by a special committee of the Illuminating Engineering Society, and also at a coming meeting of the Society on May 9th.

One of the chief needs at the present time is undoubtedly to awaken a deeper appreciation of the value of science on the part of the general public. In this respect we believe that the scientific and technical press, which offers a unique channel for the dissemination of information amongst the manufacturers of the country, could do good service, and that impartial suggestions and criticism emanating from this source would be very helpful. The best method of utilising this assistance is a matter for further deliberation and doubtless the Committee of the Council on Industrial Research will consider how the efforts of the State can best be seconded by the press of the country.

For the moment we only wish to put on record the desire of the Circle of Scientific, Technical and Trade Journalists to be of assistance—a desire which is fully expressed in the following resolution, passed at the meeting on March 14th :—

" *That this meeting recognises that Technical Education and Industrial Research are of great benefit to the manufacturers of this country.*

" *That the Circle of Scientific, Technical and Trade Journalists is prepared to assist the promotion of unity of effort on the part of the various Associations and Committees engaged in the study of the subject.*

" *That the Scientific and Technical Press be used as a medium for the dissemination of information of value to the industries of the country, thus bringing about a fuller appreciation of the value of Technical Education and Industrial Research.*"

No doubt the movement thus commenced for promoting the concerted action of the press in dealing with these important matters will lead to useful results—especially in the direction of promoting unity of effort on the part of the various organisations now discussing these problems.

Future Possibilities in the Design of Instruments for Measuring Illumination

The measurement of light and illumination has been frequently discussed by the Illuminating Engineering Society in the past, and on each occasion distinct advances towards the simplification of apparatus for this purpose were recorded. The measurement of illumination is undoubtedly a much more familiar process than it was a few years ago, and the progress in this respect has doubtless influenced the tendency towards greater precision in studying lighting requirements. The definite values suggested in the recently issued Home Office Report on Lighting in Factories and Workshops furnish an illustration of the fact that our ideas regarding these requirements are becoming crystallised, and that therefore the provision of instruments for testing whether these ideas are realised in practice is now a matter of more than academic importance.

It was therefore thought that the time was ripe for a general survey of the subject. The discussion arranged before the Society on February 22nd was productive of much useful information. There was a general recognition that for many purposes apparatus even simpler and more convenient than that available at present would be useful. Instruments of this type need not be extremely accurate ; they would be used merely to furnish a rough working idea of the illumination in a room or factory and should be capable of being used by managers and others who are not necessarily experts in photometry.

On the other hand, we agree with the Chairman (Mr. Goodenough) in thinking that a distinction must be drawn between instruments which are intended for general experimental work, where a fair margin of error is permissible, and apparatus intended for use in determining whether a lighting contract has been complied with, and whether a penalty for failing to provide the requisite illumination is to be imposed. No doubt in such cases accuracy is the chief essential and it might be desirable to employ a more complex and finished form of instrument in order to reduce the margin of error within desired limits.

In the course of the discussion some interesting suggestions for the simplification of illumination photometers were made by Mr. A. Cunnington and Mr. Trezise. The former showed a rough model of what may be termed an " illumination-gauge " enabling a reading of illumination to be obtained by mere inspection, and without its being necessary to manipulate the parts of the instrument in order to secure photometric balance. It will be recalled that an instrument having this quality was suggested by Mr. Haydn T. Harrison at a meeting of the Society in 1910, and it is possible that a very simple and cheap instrument might be produced on these lines for rough work.

Mr. Trezise exhibited a series of models of experimental photometers, an interesting feature of which was the use of a special screen, utilising an inclined piece of white glass cut with a diamond ; this appeared to be highly sensitive and to enable exact photometric balance to be readily obtained. In several of these instruments the method was adopted of bringing the lamp very close to the illuminated screen, thus rendering it possible to obtain a wide range of readings and to reduce the instrument within small dimensions.

Passing on to other points in the discussion we should like to refer to the useful information afforded regarding the possibilities of " direct-reading " photometers based on physical and chemical methods, a most interesting account of some of the work done on the Continent and in the United States being given by Prof. Féry (Paris), Dr. Ives (Philadelphia, U.S.A.) and Dr. Coblentz (Washington, U.S.A.). These contributions furnish a striking instance of the value of the international connections of the Society.

During recent years the possibility of using selenium and photoelectrical cells for photometry has been the subject of much careful study. The experimental difficulties are no doubt great but our knowledge of the peculiarities of such cells has been considerably increased, and it is conceivable that in the future these obstacles may be overcome and that an instrument resembling a form of "artificial eye" may yet be developed Meantime, it is interesting to observe that selenium has already been in use for the automatic control of lighting systems, the lamps being automatically turned on in darkness, but extinguished in daylight. Even at the present stage it seems well worth consideration if an apparatus capable of turning on the artificial light in schools and factories when the natural illumination has fallen to a prescribed value could not be worked out.

The use of photographic methods for photometry was discussed by several contributors, but at present it seems evident that this method, while useful for purely relative results with one and the same illuminant and in special researches on very faint or transient light-effects, is not very suitable for comparing different types of lamps

In some respects the most hopeful type of direct-reading photometer is that depending on the use of thermopiles which react to radiated energy of all kinds. In this case it is necessary to create an "artificial eye" by obstructing the radiation which is non-luminous or to which the eye is comparatively insensitive. Accordingly special prismatic devices or coloured solutions have been employed, and it appears that in this way very consistent results have already been obtained in the laboratory, even when lamps differing considerably in the colour of their light have been compared. One would imagine that for laboratory work such instruments would have special fields of utility, especially in confirming experimental work on standards or in recording very small and scarcely detectable changes in candlepower. Every photometric worker knows how easily such work may be upset by personal peculiarities in the eyes of the persons reading the photometer, and how results have to be checked again and again before they can be accepted as correct. In such cases a confirmatory experiment with a photometer might be of great value.

On the other hand it would seem that at present such instruments are too delicate, and the electric currents utilised too small, for them to be employed in portable illumination photometers for practical work. It should not be assumed, however, that we have reached finality in this respect. The work already accomplished has at least enabled us to appreciate the difficulties to be overcome, and it may be that in the future the hope of a direct-reading physical photometer will yet be realised. Seeing that progress in illuminating engineering is so dependent on convenient and accurate methods of measurement the study of these problems is extremely important, and we hope that friends in this country and abroad will continue their researches which should bear good fruit in time to come.

L. GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

SOME FUTURE POSSIBILITIES IN THE DESIGN OF INSTRUMENTS FOR MEASURING ILLUMINATION.

Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, London, at 8 p.m., on Tuesday, February 22nd, 1916.

A Meeting of the Society took place as stated above, on Tuesday, February 22nd, Mr. F. W. GOODENOUGH being in the Chair.

The Minutes of the last meeting having been taken as read the names of the last applicants for membership at the last meeting* were read out again, and these gentlemen were formally declared members of the Society.

The Chairman then called upon Mr. Dow to open the discussion by presenting a series of contributions received in writing from various members of the Society. These included Mr. A. P. TROTTER, Mr. HAYDN T. HARRISON, Mr. P. J. WALDRAM (London), Dr. E. W. MARCHANT (Liverpool), Prof. C. FERY (Paris), Dr. H. E. IVES (Philadelphia). In presenting these communications, Mr. Dow explained that the authors had been invited to reply to the series of questions drafted to indicate the general scope of the discussion (see p. 80). Several of the contributions dealt specially with the applications of direct-reading instruments of the "physical" type.

An interesting discussion followed, in which Mr. A. CUNNINGTON (L. & S.W.R.), Mr. J. W. T. WALSH (National Physical Laboratory). Mr. J. M. TREZISE. Mr. R. WHIPPLE (Royal Meteorological Office), Mr. G. L. ADDENBROOKE, Mr. W. R. COOPER, Mr. L. GASTER, and THE CHAIRMAN took part.

In conclusion THE CHAIRMAN announced that the **next meeting** of the Society would take place at **5 p.m.** on **Tuesday, March 21st,** when there would be a discussion on "Some Aspects of the Design and Use of Glassware in relation to Natural and Artificial Illumination."

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* *Illum. Eng.*, Feb. 1916, p. 41.

SOME FUTURE POSSIBILITIES IN THE DESIGN OF INSTRUMENTS FOR MEASURING ILLUMINATION

(With Special Reference to Photometers depending on Physical and Chemical Methods).

The following list of queries was prepared as an introduction to the discussion which took place at the last meeting of the Illuminating Engineering Society on February 22nd. It is not intended to be exhaustive but to serve as an indication of the general scope of the discussion.

(1) What possible methods can you suggest for making illumination photometers of the ordinary type (*i.e.*, those involving the use of a comparison source of light) more convenient for the use of the general public ?

(2) What are the prospects of making a satisfactory instrument depending on :—

(A) the principle of "extinction," *i.e.* diminishing the illumination to be measured until some small object just becomes invisible to the eye ?

(B) the observation of fine type—a minimum illumination being indicated by the fact of fine type becoming indistinguishable when viewed by the prevailing illumination at the point studied ?

(3) What are the prospects of making a satisfactory instrument depending on the following physical or chemical methods :—

(A) The use of selenium or other photo-electric cells.

(B) The use of thermopiles or other instruments for measuring radiation with or without a suitable solution or screen for absorbing the non-visible rays.

(C) The difference in expansion of two metallic elements, one polished so as to reflect a maximum of visible light, the other coated with an absorbent mat black material, but otherwise similar.

(D) The use of photographic methods such as the darkening of light-sensitive paper.

(4) What instances can be quoted of the above principles being used successfully in other fields of photometry, for example, in records of daylight, meterological observations, determining polar curves, observing fluctuations in the light given by various lamps, &c.

(5) Are you aware of any methods which could conveniently be employed in the design of instruments to indicate automatically when the illumination in an interior has fallen below a prescribed minimum, and an increase in the illumination is therefore necessary ?

SOME FUTURE POSSIBILITIES IN THE DESIGN OF INSTRUMENTS FOR MEASURING ILLUMINATION

(With Special Reference to Physical and Chemical Methods).

(Discussion at a meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 8 p.m., on Tuesday, February 22nd, 1916.)

THE CHAIRMAN, in declaring the discussion open, mentioned that a number of contributions had been received from various members at home and abroad, in reply to the series of queries circulated previous to the meeting. He would call on Mr. Dow (Asst. Hon. Secretary) to present these communications.

Mr. J. S. Dow (Hon. Asst. Secretary), in presenting the written contributions to the discussion, remarked that a considerable amount of work had been done, both in Europe and in the United States, on instruments intended to serve as direct-reading photometers. As this work could be only briefly touched upon in the time available, members might be interested in the series of references given below based on information kindly

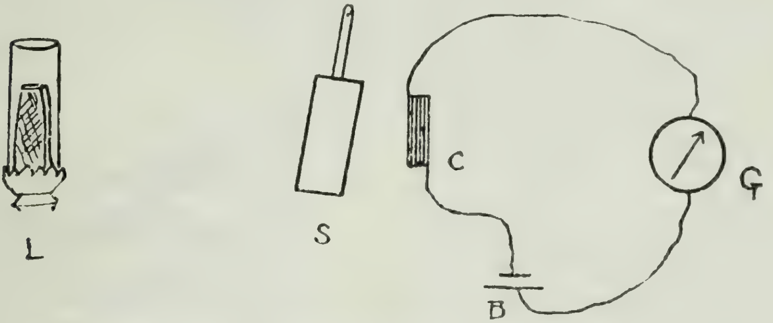

FIG. 1.—Arrangement of circuit for selenium cell (Ives).
L, Light source ; S, Shutter ; C. Selenium ; D. Battery ; G. Galvanometer.

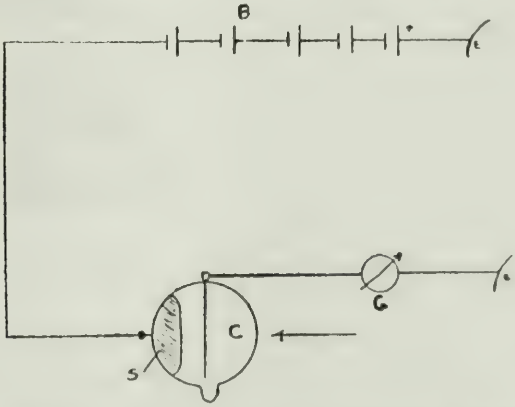

FIG. 1A.—Arrangement of Circuit for photo-electric cell (Ives).
B, Battery ; C. Cells ; G. Galvanometer ; E. Earth.

furnished by various members of the Society.* There had also been several past contributions in the ILLUMINATING ENGINEER, describing attempts to use photo-electric and other light-sensitive cells and also thermopiles for photometric work.†

As a preliminary to the contribution by Dr. Ives it might be of service to summarise briefly some of this earlier work. Attempts had been made to use both the selenium cell, the electrical resistance of which diminished under the action of light, and the photo-electric cell devised by Elster and Geitel. The essential arrangements for using such cells are shown in Figs. 1 and 1A (taken from a recent paper by Ives). In both cases the diminution in resistance, and hence the increased current furnishes an indication of the intensity of the light falling on the cell. Such methods necessarily involve the use of a battery and galvanometer and this fact alone does not seem to favour their use by inexpert observers for making illumination measurements in practice. In addition there appear to be various difficulties arising from the physical peculiarities of such cells, such as the effect of inertia and other irregularities; and there is the further difficulty that the greatest effect is not produced by those rays in the spectrum to which the eye is most sensitive. In the case of the selenium Pfund has shown that the relative sensitiveness throughout the spectrum is utterly different in a weak light from what it is in a strong illumination—in this respect bearing a curious resemblance to the Purkinje effect in the case of the human eye. This is shown in the accompanying illustration.

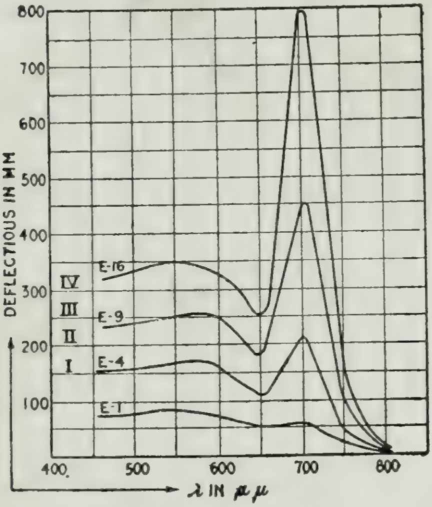

FIG. 2.—Showing the variation in relative sensitiveness throughout the spectrum of a selenium cell at different Illuminations. (E=1 to E=16.)

In Fig. 3 the comparative sensitiveness throughout the spectrum of various photographic materials is illustrated. Obviously the selection of a material having a sensitiveness identical with that of the eye would present difficulties. Moreover, photography, although having certain applications, is in general a tedious operation compared with the use of a good

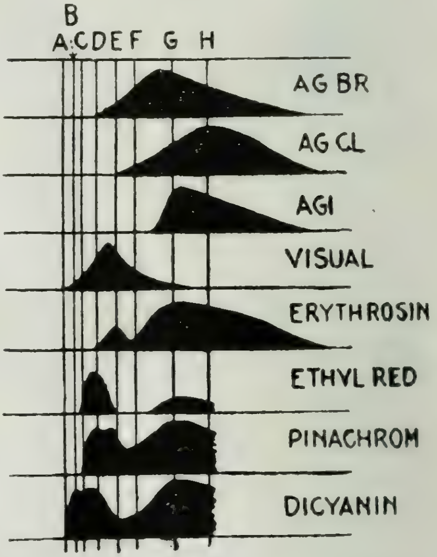

FIG. 3. — Showing differing sensitiveness throughout the spectrum of various photographic materials (Ives).

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* Physical Photometry, by H. E. Ives (paper read before the Illuminating Engineering Society, U.S.A., November 7th, 1914); The Establishment of Photometry on a Physical Basis, by H. E. Ives (*Jour. of The Franklin Institute*, October, 1915; A Precision Artificial Eye, by H. E. Ives (*Phys. Rev.*, November, 1915); The Physical Photometer in Theory and Practice, by W. W. Coblentz (*Jour. Franklin Inst.*, February, 1916), &c.

† See "Objective Photometry," by W. Voege (*Illum. Eng.*, Vol. VII., 1914, p. 295; also Vol. I., 1908, p. 239, Vol. II., 1909, p. 10.)

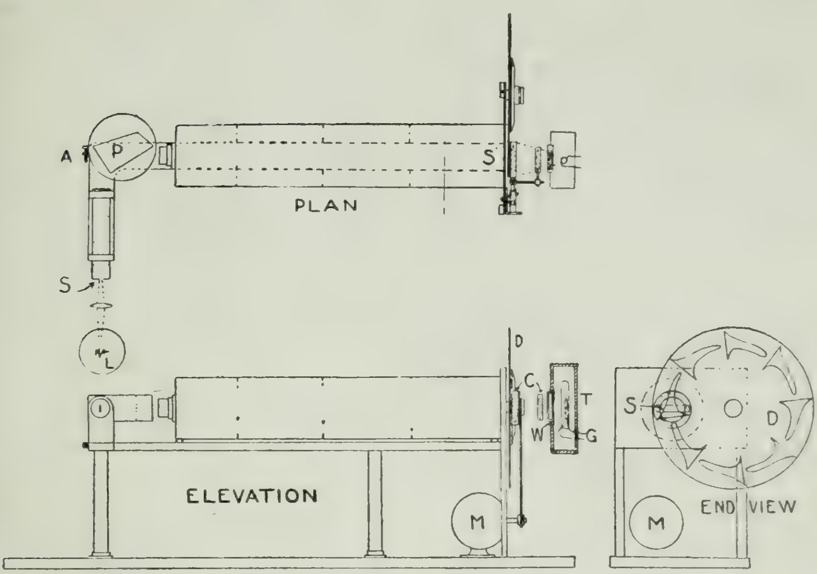


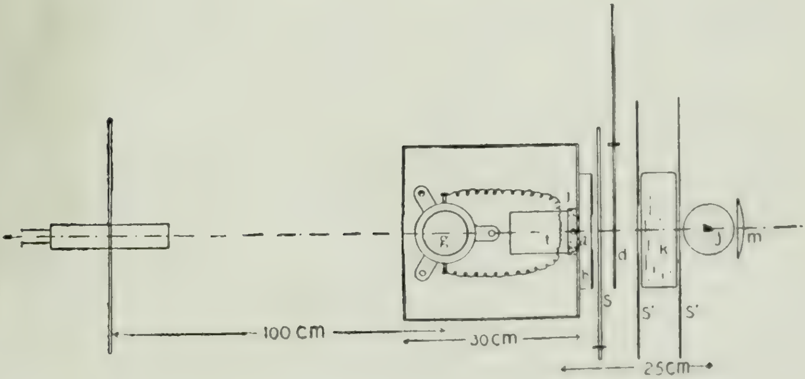
Diagram of precision artificial eye.

L. Light source.
S Slit
P Prism.

A. Adjusting screw
S′ Point of formation of spectrum.
C Condensing lenses

T. Thermopile.
D. Spectrum template.
G. Galvanometer leads.

FIG. 5.—Instrument devised to give the effect of "Artificial Eye" (Ives).
(Using prismatic method.)



Physical photometer

t. Thermopile.
g. Galvanometer
l. Luminosity curve solution.

s Shutter.
d. Sector disk.
s′ Screens.

k. Water tank
j. Light source.
m. Concave mirror.

FIG. 6. Physical photometer (using cell of special solution).

illumination photometer. A special instance of the utility of photography is furnished by some experiments by Ives on obtaining polar distribution curves; photography has also the advantage of integrating with regard to time, and has therefore a special application for purely relative measurements of sources which fluctuate very rapidly over a short interval of time. (Tests on the "star-shells" used in military operations might furnish a case in point.)

Passing on to the use of thermopiles special reference may again be made to a paper by Ives in which the creation of an instrument to serve as an "artificial eye" is discussed. Fig. 4, taken from this source, shows at a glance the difficulty of the problem. By special absorbing methods we have to obliterate the great mass of the radiant energy, leaving only the small shaded area representing luminous radiation. The amount of energy left is then very small, and highly sensitive instruments are needed to measure it.

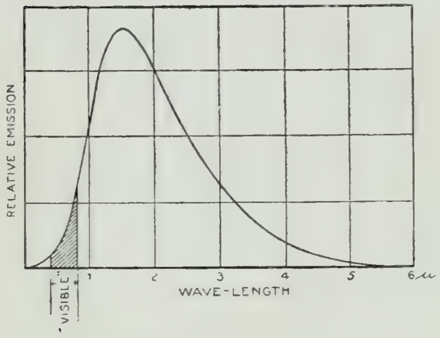


FIG. 4.—Showing that the visible rays form a relatively small proportion of the radiation from an incandescent solid.

Two methods of accomplishing this result are described by Ives and illustrated in the Figs. 5 and 6. In one case a cell of special coloured solution is used. This has the function of not only stopping the non-luminous energy but of diminishing the intensity of each wave-length throughout the visible area in such proportions as to render the effect identical with the sensation of the eye. (This method is also used in an instrument devised by Prof. Féry, see p. 88.)

In the other case the same result is accomplished by forming the spectrum of the light to be tested, diminishing the intensity at each point in the requisite proportion by means of a special sector-screen, and then integrating the spectrum and focusing the resultant light on a thermopile.

All this work is highly interesting and such instruments appear to have distinct value for laboratory work. But at present they do not appear to be capable of application in the form of a portable illumination photometer for every day use.

Mr. Dow then proceeded to present the communications of various absent members, as follows:—

A. P. TROTTER (*communicated*):—

(1) I do not think that "*the general public*" should be encouraged to amuse themselves with illumination photometers. Some experience is necessary and intelligent precautions must be taken to secure useful results.

Instruments of the lumeter and the luxometer type, having wide ranges of adjustment in addition to dark glasses, are bound to supersede the older instruments.

2. Physiological difficulties render all methods of "extinction" and "minimum visibile" misleading.

3. The differential bolometer depending on the resistance of a fine wire seems to be the best method depending on direct physical measurement: but it entails the use of expensive apparatus.

LIEUT. HAYDN T. HARRISON, R.N. (*communicated*):—(1) In my opinion it is essential that photometers for the general public should not embody the use of an eye piece, as few people can accustom themselves to work with one eye as accurately as they can when taking a general view of a screen with both eyes.

(2) (A) Satisfactory instruments can be made embodying the principle of extinction, but in order to get such extinction the colour difficulty should be carefully considered, and a standard light of similar spectrum used, otherwise the flicker principle is the more accurate when

the operator is not an expert photometrist.

(B) I do not consider any light measurements by means of type can be of much value, as it is more a test of eyesight than illumination.

(3) (A) I have had considerable experience with selenium, but find that the greatest care has to be exercised in the preparation and maintenance of the selenium cell; there is, moreover, a time lag which is often a serious disadvantage.

(B) The use of thermopiles or other instruments for measuring heat with screens for absorbing heat rays, strikes me as being novel, and I cannot imagine that a true luminous value could be measured by this means.

(C)————

(D) The use of photographic methods to indicate distribution of light will always be of value, but as an indication of intensity they are generally misleading owing to the emphasis laid on the violet or actinic end of the spectrum. As is well known, photo-productions can be made by invisible rays, whereas I always look upon light as the usable part of the spectrum.

(4) I have seen many photographic records indicating the fluctuations in arc lamps, and also light absorption by the deposit on the bulbs of incandescent lamps, but these of course were purely comparative, and could not be defined in terms.

(5) Not at the moment.

Mr. P. J. Waldram (*communicated*) :— With reference to questions 3D and 4, I have been impressed by the remarkable coincidence between the measurements of daylight given by sensitised paper, exposure meters, &c., and direct measurement on a photometer by different observers. It would appear that the decided irregularities of actinic action are very possibly immaterial.

Work of a very different and more urgent nature has so far rendered impossible any experimental investigation by me; but I venture to anticipate with some confidence that sensitised paper photometers may some day be found to be sufficiently free from serious error to enable it to be applied to many practical every-day problems.

I may also recall the striking resemblance which was noted by the Meteorological Office between the curve of lumeter measurements of daylight on a certain day, as given in my paper in 1914, and the daily curve recorded by them of the radiant energy from the sky. This is another problem which awaits experimental proof.

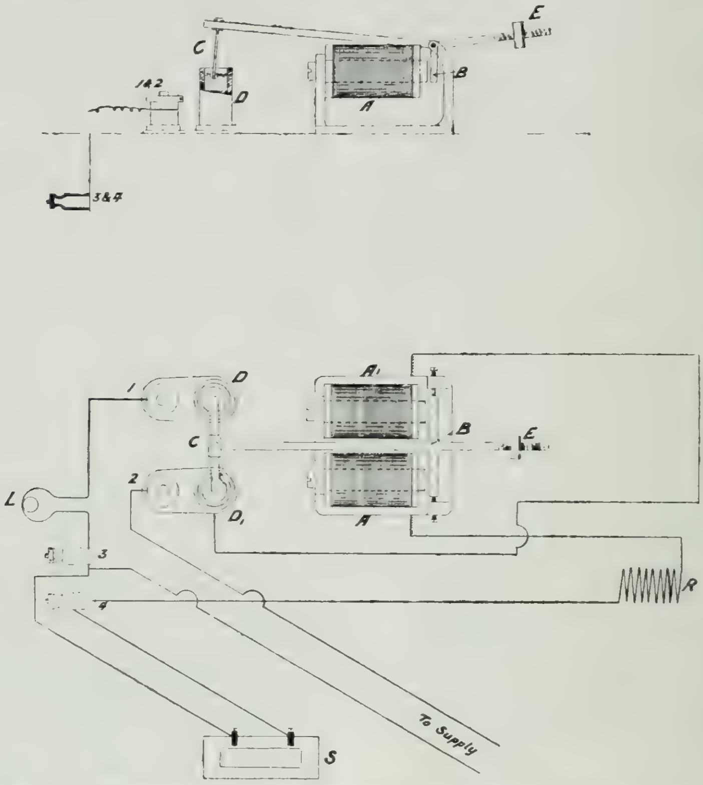
Prof. E. W. Marchant (*communicated*) :—The forms of illumination meter that I have used are the "Trotter" Illumination Meter and that made by Messrs. Beck, called the Holophane Lumeter. Both of these are quite convenient and simple. The chief practical difficulty with them is the keeping of the battery in good order; when, as often happens, they are not used for comparatively long periods, it is always necessary to use some form of voltmeter in connection with them, and I would suggest that this might be fitted to the instrument together with some correction tables by which the readings of the instrument may be corrected for variations in lamp voltage. It might be possible to devise some mechanical device whereby the readings were automatically corrected for variations in battery pressure.

An instrument depending for its reading on extinction of vision seems to me to have very small prospect of accuracy. The acuteness of vision to light depends on the opening of the pupil, and on the condition of the retina, and this varies with the immediate previous history of the eye. A photometer of a simple pattern for photographic purposes has been suggested in which this fact was made use of. I have no detailed information as to its construction, but the principle of its action was that an image of the pupil was produced by a semi-reflecting glass, and on this mirror, the diameter of the image of the pupil could be read off on a scale. This can only have been a rough and ready instrument, but for many purposes it might prove of value.

I had the opportunity of seeing an instrument some years ago, designed by Mr. Turner, the electrical engineer to the Hoylake District Council, which depended for its working on a selenium cell.

Mr. Turner has kindly contributed a detailed account of his apparatus. Its object was to switch on a street lamp when the illumination fell below a certain limit determined by the resistance of the selenium cell. Such a piece of apparatus has great possibilities, and might easily be applied in schools as an indicator as to when the lights should be switched on.

For accurate comparison of illuminations I have found nothing better than the Lummer Brodhun Photometer, which I hope, by now, is being manufactured in England. Even with lights of different colours I have found that, with practice, it gives excellent results, far better than I have been able to obtain with Flicker photometers.



SKETCH OF MR. C. J. TURNER'S SELENIUM APPARATUS FOR CONTROLLING THE LIGHTING SYSTEM.

The selenium cell, S, is inserted in circuit with two electromagnets, A, A1. The ligting circuit contains the mercury cups, D, D1, which are connected by the forked contact piece, C, attached to lever-bar controlled by electromagnets. B is the pivoted armature attracted by the magnets. E is an adjustable balance weight for altering moment of contact, R a resistance placed in circuit with magnet coils (in this case about 14,500 ohms), L the lamps controlled by action of selenium.

Selenium has the property of diminishing in resistance when exposed to light; the variation in this case being from 3,000 ohms. in light to 150,000 ohms in darkness.

In full daylight, therefore, a relatively strong current flows round the magnets, which draw up the armature breaking the circuit at the mercury cups, D, D1. The lamps are thus extinguished.

When darkness comes on the resistance of the selenium increases and the current energising the magnets is diminished until, eventually, the armature is released and current is established at the mercury cups lighting the lamps.

The exact point of switching on can be regulated by the balance weight, E.

Dr. H. E. IVES (*communicated*):—I was interested to learn of the forthcoming discussion of physical photometry in the London Illuminating Engineering Society. It hardly seems necessary to repeat the opinions and experiences already published in my recent and somewhat exhaustive papers on the subject. It may, however, be of interest to mention some more recent work which has not as yet appeared in print, or on which we are working or merely contemplating work.

In regard to the photo-electric cell, it may be recalled that a most serious objection to its use is the lack of direct or uniform proportionality between the illumination and the current. This is a subject on which we have been working for some time, and we have rather recently established the conditions under which this important relationship is strictly rectilinear. As a result of this work a new design of photo-electric cell has been worked out, in which the current does not vary in unexpected ways from the illumination. With this improvement in the photo-electric cell it is a wonderfully sensitive instrument for use where no questions arise as to colour differences. There still of course remains the disadvantage that apparently no two photo-electric cells have the same wave-length sensibility curve. This is one of the problems on which we are doing some work at the present time. Should it prove possible to make cells of uniform wave-length sensibility, so that a luminosity curve sensibility could be produced by the proper absorbing media, then the photo-electric cell would be probably the most sensitive and convenient of all forms of physical photometers.

In regard to the thermopile physical photometer, which is described in a number of recent papers, this instrument is working admirably in practice. Its only drawback of course is that its sensibility is so low that it can only be looked upon as a laboratory instrument. Since, however, it is being rather generally agreed upon now that all photometric work involving colour differences should be done in a standardising laboratory, this objection is not at all serious.

In connection with this question of sensibility I may say that I am at present very much interested in the possibility of increasing the effective sensibility of all kinds of radiation measuring instruments by some sort of current amplifier along the lines of those which have been recently developed for wireless telegraphy and telephony. There is, however, nothing definite to report on this beyond the fact that the possibility is an attractive one and is receiving attention.

DR. W. COBLENTZ (*communicated*) :—In connection with the question of the " Possibilities in the Design of Instruments for Measuring Illumination," physical methods demand a careful unbiased investigation. A measurement made with a physical instrument is a definite thing that can be repeated at any time with the expectation of obtaining the same value as was observed in the beginning. The physical photometer is not subject to such vagaries as are experienced in visual photometry. The instrument, as we know it, is not so sensitive as visual photometry. It requires fairly high intensities but for certain classes of work is not detrimental.

A promising form of physical photometer consists of a quick acting thermopile in front of which is placed a screen which is opaque to all the infra-red and ultra-violet radiations, and which transmits the visible radiations in proportion to " visibility of radiation curve " of the average normal eye. The thermopile or bolometer is used in connection with a sensitive d'Arsonnal galvanometer, or (when radiometering low intensities) with an iron-clad Thomson galvanometer. Iron-clad Thomson galvanometers are easily and cheaply made by imbedding the coils in blocks of Swedish iron, which are surrounded by short pieces of soft iron gas pipe. Such a galvanometer is easily shielded magnetically, so that the objections raised by experimenters, who are familiar with unshielded Thomson galvanometers, are overcome.

A physical photometer of this type, unlike the eye, functions independently of the frequency (colour) and the intensity of the stimulus. During the past summer the writer made a short test of the performance of this type of physical photometer as compared with a visual (equality of brightness) photometer, in which the test object was a standard incandescent lamp, which had been photometered by various observers in various laboratories. The ratios of the luminous intensities of a standardised tungsten lamp, determined photometrically, and radiometrically with the physical photometer, were found in agreement within 0·2 per cent. This is a very close agreement, considering the fact that the radiometric measurements were obtained in the course of a few hours, while the photometric measurements represented several weeks of work. This close agreement is not accidental, however, for the physical photometer is not subject to variations such as are common to the eye, and it must give the same result from day to day.

Subsidiary questions remain for further investigation. The example the transmission of the solution used in front of the thermopile seemed to change slightly after several exposures to the lamp, and it remains to be determined whether this was due to a photochemical reaction which is reversible. For further data the reader is referred to the Journal of the Franklin Institute, September, 1915, and February, 1916; also *The Physical Review*, November, 1915.

PROFESSOR C. FERY (*communicated*) :—I have been prevented from following up the study of a new form of photometer by very urgent work given me by the Commission of Inventions. I must therefore ask you to excuse me for not having given you yet the details of this new apparatus. The instrument is described in the *Bulletin de la Société Internationale des Electricians* (Series 2, Vol. IX. No. 90).

The only methods practically employed for measuring light depend on the impressions of the eye, as received by observation of two adjacent illuminated surfaces in a photometer. This method necessarily involves the employment of a standard of light, and, being subject to a physiological impression, there is always the danger that the results of measurement will depend on the visual peculiarities of the observer.

I have made observations on a number of my pupils, and have found that considerable personal differences exist. No doubt Daltonism would play a part in cases where the colours of light yielded by standard and source tested are not the same. The use of a monochromatic (Crova) screen has not appreciably affected the mean, but has caused to disappear the large differences previously encountered in the readings of different observers.

It would therefore be very desirable to adopt a "direct-reading photometer" or an "artificial eye," to use the expression adopted by Ives in his experiments.

Among the forms of direct-reading instruments are those depending on :—

(1) The use of a selenium cell.

(2) The use of a photo-electric cell.

(3) The use of photographic preparations.

(4) The use of apparatus for measuring total energy radiated by the incandescent body.

No. 1 has the inconvenience (among others) that the indication is not proportional to the luminous sensation, the maximum sensitiveness of which for the normal eye is located at 0·54μ. Moreover, the cells are not constant and their sensitiveness diminishes with time.

No. 2 is open to the same objections.

No. 3 yields with silver salts a maximum sensitiveness near 0·34μ; moreover, it is necessary to estimate the light-effect by measuring the opacity of the image on the plate, and this is by no means proportional to the illumination. The use of ortho-chromatic and other colour-sensitive plates removes the first objection but not the second.

No. 4 appears the best worthy of examination. The response of a bolometer depends on the temperature of the incandescent source, being related by the Law of Wien :—$\lambda_m\theta =$ constant. The method has therefore a tendency to favour sources of low temperature, just the opposite to the tendency with photographic methods.

Nevertheless it is possible to get over this difficulty by the use of suitable screens. In 1908 I employed with success a radio-micrometer combined with a screen composed of a solution of copper acetate in order to provide a direct-reading photometer, giving the same sensitiveness throughout the spectrum as the normal eye. More recently I have used such cells with a thermopile. The use of my solution gives a system with a maximum sensitiveness near 0·54μ, identical with that of the retina; to achieve this result a thickness of 4 cms. of copper acetate solution (17 grms. per litre) is used.

One could also stop the invisible radiation by using a prismatic arrangement instead of screens. For this purpose one must form a spectrum image of the source to be tested, placing in front of it a screen cut in such a way that the ordinate at each point is proportional to the luminous impression received by the retina. The radiation is then integrated and received on the instrument for measuring the radiation. This arrangement is theoretically very successful, but in practice may be replaced by a cell filled with suitable absorbing liquid. One can make use of a bolometer of the type described by Dr. Drysdale for determining the mechanical equivalent of light, a galvanometer of the type worked out by Ives, or a Boys' radio-micrometer modified in the manner described in my researches. I have likewise employed an invar-brass couple similar to that used in the spiral pyrometer constructed by the Cambridge Scientific Instrument Co.

The bi-metallic strip was blackened on the side facing the radiation, and carried a quartz fibre, the movement of which could be measured with a microscope. By this simple procedure I think one could arrive at a sensitiveness sufficient for practical purposes.

The war has interfered with these experiments. I am convinced, however, that the photometer of the future will be of a type independent of the personal peculiarities of the observer, for the invariable tendency in physical matters is to devise methods of measurement which are independent of physiological processes. Chronography and astronomy have replaced the ancient measurements dependent on the eye and the ear. Similarly I believe that by a calorific measurement one can best evaluate the intensity of radiant energy.

Mr. ARTHUR CUNNINGTON (London and South-Western Railway Co.), dealing with the first question said that although Mr. Trotter did not advise that photometers should be made for the use of the general public, nevertheless something might be done in order to simplify readings. In some quarters there was a tendency to exaggerate the difficulty in making illumination measurements, which he thought was due to being unaccustomed to this sort of work. Some people even could not read a gas meter correctly, but it was simply because they were not used to doing it, and he was of the opinion that with a little practice it would be a simple matter, with a suitable instrument, for any ordinary person to take photometric readings. We had already progressed very considerably from the days of the purely laboratory photometer, and there were various directions in which simplification could be carried still further.

When he first began taking measurements on a fairly extensive scale with the Lumeter, he found one thing required was something to hold the illumination card in a horizontal position, especially when a large number of measurements were being taken over an area, in a horizontal plane at some fixed height above the ground. He was aware that a tripod stand was supplied for this purpose, but moving and resetting this for several dozen successive readings was a tedious process, and one could not always afford the luxury of an assistant. Therefore, in order to make the instrument self-contained, he had designed a form of adjustable holder which could be attached at one end to the lumeter by a spring clip, and at the other end carried the white screen. This, he had found, saved a great deal of time.

He had often noticed that a rough test of the uniformity of illumination in a given area could be made by setting the lumeter at some average figure and,while keeping this fixed illumination in view, moving from place to place and noting where the illumination differed widely from the average.

This principle of setting the Lumeter at a given point suggested the use of an instrument with several of such fixed values, in which no scale would be required, but in which the illumination would be roughly gauged by observing which of the values most nearly balanced with the existing illumination. He exhibited a model of an instrument of this type (for the making of which he was indebted to his father), and showed a slide illustrating it (Fig. 1). The top surface of the box consists of a white screen with a number of spots upon it illuminated from behind. Various degrees of illumination are obtained by varying the size of the holes in the middle diaphragm, and thus altering the area of the light source available. The light from the lamps in the lower part of the box shines through opal glass, or other translucent material to give uniformity of illumination, and this lower part is whitened throughout in order to secure the maximum diffusion.

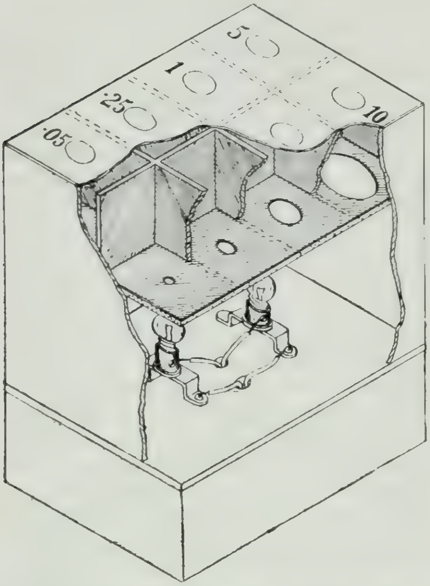


FIG. 1.—"Box Photometer" (Mr. A. Cunnington).

The battery can be fixed under the box or at one side of it. The chief points in a scheme of this sort are:—

(1) That no manipulation is required.

(2) That it shows at a glance the general character of the illumination, and changes can be readily detected.

(3) That, as the instrument has not to be carried at eye level, the battery can be contained within it.

This idea might be developed still further and made in a very compact form for a single standard, by using an ordinary torch lamp with accumulator, and fixing in front of it a screen illuminated to exactly some prescribed value. Such a pocket standard might be useful for rough testing in factories in order to be sure that a minimum illumination was obtained.

In all these arrangements some form of battery was necessary, and that was certainly a drawback, although he thought the difficulties of dealing with a battery were often much exaggerated. It was important to have a voltmeter available to check the voltage of the cell, and to know when it was failing. He was interested in Prof. Marchant's suggestion as to using correction tables, as he had been in the habit of making a percentage correction in readings when the voltage of the cell varied from the normal. It might be convenient to scale the voltmeter not in "volts" but in "percentage error," with a centre zero at the normal voltage of the cell. He did not recommend that such an instrument should be permanently attached to the photometer, but should be capable of being clipped across the terminals of the cell whenever required, and would then indicate directly the correction to be made, if any.

At the same time it should be remembered that a battery of reasonable capacity remained steady for a long time, and he had often used batteries for several weeks on end, taking readings constantly without any trouble. A rough indication of falling voltage could be obtained at any time by simply holding on the switch of the Lumeter and observing whether the illumination inside remained constant or gradually diminished. He strongly deprecated, for practical illumination measurements, the carrying about of what was equivalent to a complete photometric laboratory. It was said to make one "independent of a laboratory." That might be true, but only at the cost of carrying the laboratory about with you. He thought all checking against standards should be done before going out to test.

With regard to the second question, Mr. Trotter had already expressed the opinion that the physiological difficulties were practically insuperable. He had, however, made a few rough experiments in the direction of an "extinction" photometer in the hope that even if only very approximate results could be obtained, there might be some field for an instrument of this class, having the great advantage of dispensing with battery and comparison lamp.

He exhibited a rough model of the arrangement as outlined in Fig. 2. The idea was to look through a transparent diaphragm on which was marked some fine lines or small type, at a background which was lighted by the illumination it was desired to measure. This background was graded in shade from very light to very dark. Then if the illumination were high a very dark background could be placed behind the diaphragm before the fine lines or type became invisible, whereas with a low illumination, they would be indistinguishable against a much lighter background. The variations in the background would thus indicate the degree of illumination. He regretted that up to the present he had not got any reliable results, so much depending on quality and condition of eyesight.

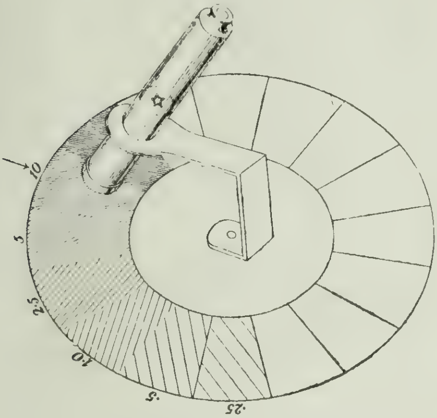


FIG. 2.—Suggested instrument based on "contrast" (Mr. A. Cunnington).

Mr. J. M. TREZISE :—

I was hoping to be able to show this evening some experimental photometric apparatus with which I was working some time ago, but I have not been able to get very much ready for the meeting. I will, therefore, confine myself chiefly to the description of a special form of photometer screen.

I was recently engaged in the design of a convenient form of portable photometer making use of a lens to view the illuminated surfaces to be compared so as to permit of the instrument being of small dimensions. I had difficulty in finding a screen which would stand much magnification without the surface appearing granular and the edge either lighter or darker than the rest of the field. I noticed, however, when making experiments with opal glass, that the broken ends of what is known as flashed opal glass (*i.e.*, clear glass with a thin opal surface on one side) presented a remarkably uniform brilliancy when viewed at a suitable angle. This evenness of brilliancy is not disturbed by the irregularity of the broken end of the glass when it is cut by being scratched on the opal side by a diamond or preferably a cutting wheel and broken. In the ordinary way this uniformity extends up to the edge of the surface of the broken end so that, when used as a photometer screen, it presents a clean sharp edge giving a fine dividing line between the two illuminated surfaces ; if the lights are of the same colour this edge disappears altogether when a balance is obtained.

I have here a piece of flashed opal glass which is very thick so that you may see the edge without magnification, and if I place it so that you are looking at the broken end at an angle of about 40° from the normal you will see the effect I have described.

The arrangement is shown in Fig. 1.

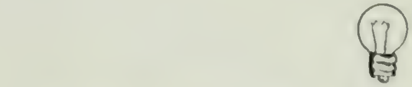


FIG. 1.—Inclined glass edge screen (Mr. J. M. Trezise).

By placing a black screen with a circular hole in it so as to hide all but a semi-circular portion of the end of the glass as in Fig. 2 we arrive at the arrangements used for the photometer in measuring surface brightness, a view of the test plate being obtained through the semi-circular dark hole at the top in instruments.

In the model, Fig. 3, which is being passed round for you to see, the glass is thinner and a lens is provided to give a field which corresponds to a circle 4 inches diameter at a distance of 2 ft.—which is sufficiently large for ordinary work.

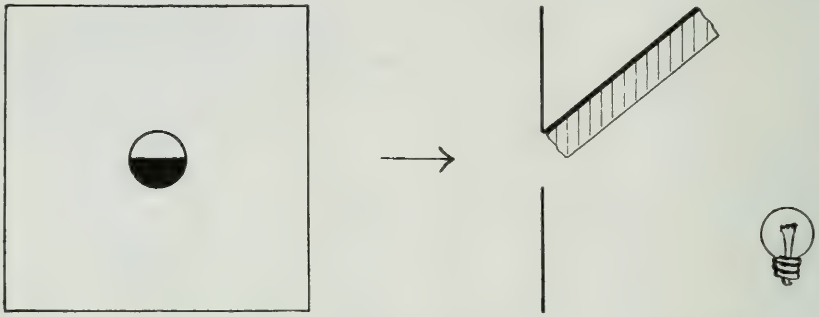


FIG. 2.—Inclined glass edge as embodied in photometer and resulting field of view (Mr. J. M. Trezise).

In Figs. 1 and 2 the light is placed on the side remote from the opal surface and the brilliancy seen is that of the side of the opal surface next the light. In this case ordinary clear glass painted white at the back may be used. In Fig. 3 the light is on the opal side of the glass and the brilliancy is less as the light is filtered through the layer of opal glass.

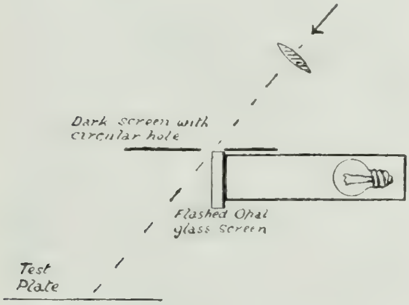


FIG. 3.—Small illumination photometer using inclined glass edge screen (Mr. J. M. Trezise).

This form of screen lends itself very nicely to photometry of small dimensions; indeed, if desired, it is possible to make quite a satisfactory instrument very small indeed. I have used one which reads from 1 foot-candle to 100 ft.-candle fixed to the objective of a microscope and which is contained in a tube $\frac{3}{8}$ inch diameter by $1\frac{1}{2}$ inch long. A somewhat similar instrument is shown in Fig. 4, a model of which is shown on the table. The variation in the brilliancy of the screen (*a*) as viewed through the lens (*b*) is effected by rotating, half a revolution, the tube (*c*) containing a glow lamp of about $\frac{1}{20}$ candlepower, and an opal glass window (*d*). When this window is opposite the piece of flashed opal glass (*a*) the brilliancy corresponds to 1 ft.-candle. When it is in the position most remote from (*a*), *i.e.*, when the tube has been turned through half a revolution, the brilliancy is 0·1 ft.-candle. By turning the cap (*e*) so as to bring the grey glass (*f*) in the line of vision the brilliancy of the test plate is reduced to $\frac{1}{10}$ of its value, and the readings on the scale increased tenfold. Thus the instrument as constructed with one piece of absorbing glass reads from 0·1 to 10 ft.-candle.

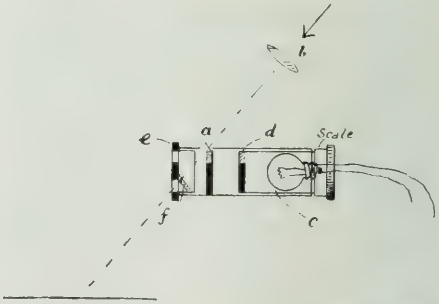


FIG. 4.—Showing use of two apertures whose relative position can be altered to vary illumination (Mr. J. M. Trezise).

The determining factor in the size of this model was the diameter of the glow lamp. I should have used a smaller tube if I could have got the smallest lamp I had into it. The lamp also gave far too much light and for instruments of this kind where it is possible to bring the lamp very close to the screen this is generally the case.

In this instance I wanted a maximum brilliancy of the screen to match 1 ft.-candle of illumination but the lamp, which is a 2·5v. lamp run at 2v. and gives about ·5 candlepower, gave 20 ft.-candles on the screen, *i.e.*, 20 times more light than is necessary.

The possibility of using a very small lamp for a portable photometer ought to reduce considerably battery troubles.

In the instrument of which Fig. 5 is a diagrammatic representation two screens (*a*) and (*b*) are used. The tube (*c*) containing a ·5 candlepower lamp is provided with an opal glass window of about ⅛ inch diameter which when it is brought close to the screen gives a brilliancy corresponding to 60 ft.-candles, and when it is moved from the screen to a distance of about 1 inch by means of the snail the brilliancy is reduced to 0·6 ft.-candles the observation being made through a lens over the aperture at (*a*). For lower readings the lens is moved to a position over screen (*b*) which is illuminated by the light passing through screen (*a*) and is placed at such a distance from (*a*) as to attain a maximum brilliancy corresponding to 0·6 ft.-candle, and this may be reduced by the movement of the lamp to 0·005 ft.-candle.

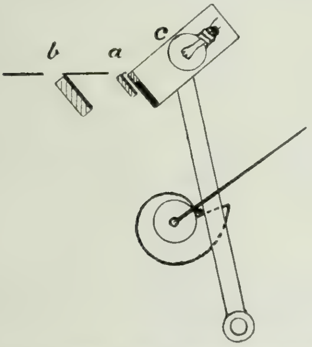


FIG. 5.—Use of two inclined glass edge screens (Mr. J. M. Trezise).

By a movement of the lamp of about 1 inch therefore the range of the instrument is from 60 to 0·005 ft.-candle and the introduction of a grey glass to reduce the brilliancy of the test plate increases the maximum to 6,000 ft.-candles or to 60,000 ft.-candles by the use of a coloured glass for daylight measurements.

I may say that in arranging the absorption glasses the necessity for exact adjustment of the glass or the use of wedges has been avoided by selecting glass of suitable colour with an absorption somewhat less than that required, the exact value being obtained by inclining the glass from the normal to the pencil of light until the required absorption is given.

By means of an opal glass screen in the line of vision the instrument may be used for candlepower measurements, and if the light to be measured is a predetermined distance from the instrument direct readings are obtained. If, for instance, the light is 7 feet away the candlepower will be the scale readings multiplied by 100. This arrangement is convenient for taking polar curves of lamps or shades.

The snail is designed to give a log scale which I have found to be the most convenient for an instrument of this kind.

Two screens may be arranged as in Fig. 6 for use as a photometer head for bench work.

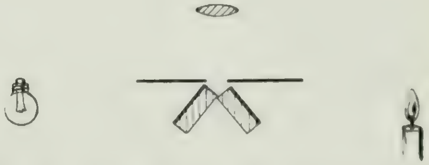


FIG. 6.—Model of photometric bench designed to show principle of instrument (Mr. J. M. Trezise).

The arrangement, when used on an ordinary bench seems to be very sensitive, but I should explain that the model makes it appear more sensitive than it really is as the lights are closer to the screens than they would be in actual practice.

The models on the table may be inspected at the close of the meeting.

Mr. J. W. T. WALSH (National Physical Laboratory) said that before venturing to offer a few remarks on the third section of the headings set out for discussion, he would like to say that he had had no first hand experience whatever of physical photometry. Photometric work at the N.P.L. had always been by visual comparison and although, shortly before the outbreak of war, the question of a research into the possibilities of physical photometry was being discussed, the matter had necessarily been temporarily abandoned owing to the large amount of more pressing work now demanding all the attention and energy of the staff. Physical photometry, originally developed along practical lines in Germany, had during the last few years—he might also say months—made great strides in the United States where several workers had published—chiefly in the Physical Review—the results of their researches on this subject. The chief methods of physical photometry might be roughly classified in two main divisions, (*a*) those employing photo-electric phenomena, and (*b*) those depending on the measurement of radiation, and involving, usually, some form of thermopile and galvanometer. He might, perhaps, be forgiven for running quickly over the basic principles underlying the photo-electric cell. In 1888 Hallwachs* discovered that a negatively electrified body lost its charge when ultraviolet fell upon it. A year later Elster and Geitel† showed that electro-positive metals, like sodium, potassium, and rubidium exhibited the same effect when exposed to ordinary light. This phenomenon, however, only occurred with freshly formed metal surfaces, for if the plates were allowed to stand in air, their activity would rapidly diminish. Later it was discovered‡ that the sensitiveness of the metal surfaces could be much increased by placing them in a bulb containing hydrogen at low pressure and causing a glow discharge to pass between electrodes sealed in this bulb. Under this treatment the metal undergoes a modification of form in the course of which its surface becomes coloured and is found to be three or four times as sensitive as that of the pure metal. The hydrogen in the tube must be subsequently replaced by argon or helium, otherwise the sensitiveness would be found gradually to diminish as time went on. The figure showed, somewhat diagrammatically, the form generally taken by a sodium or potassium photo-electric cell. C is the cathode wire in contact with M the active metal, while A is a wire anode. The metal has undergone the preliminary treatment with hydrogen described above and the globe is filled with either argon or helium. On applying a potential of say 6 to 12 volts between A and C, and illuminating the surface of M, a current is found to flow through the cell. This current is exceedingly small, generally of the order of 3 by 10^{-10} amps, per foot-candle, but it has been found to be

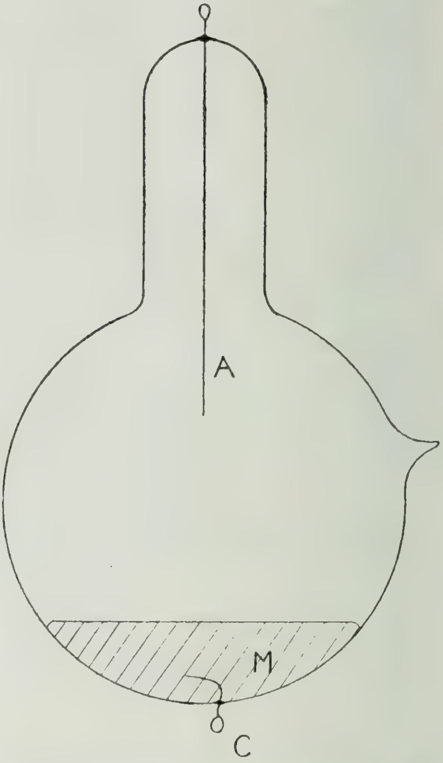


FIG. 1. -Usual form of Elster and Geitel photo-electric cell (Mr. J. W. T. Walsh).

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* Hallwachs, *Ann. d. Physik*, 33, pp. 301—312, 1888.

† Elster and Geitel, *Ann. d. Physik*, 38, pp. 40, 497, 1889.

‡ Elster and Geitel, *Phys. Zeitschr.*, 11, pp. 257—262, 1910; 12, pp. 609—614, 1911.

accurately proportional to the degree of illumination of the metal surface over the extremely wide range of 0.01 to 620 foot-candles. Richtmyer, in America, had described an ingenious null-method of photometry by means of such photo electric cells.* His apparatus consisted of two similar cells arranged with two sources of potential after the manner of a Wheatstone Bridge as shown in the figure.

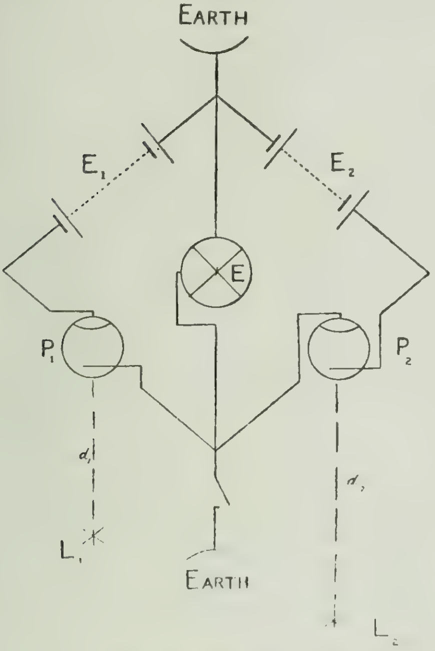

FIG. 2. Connections for using photo-electric cells on Wheatstone Bridge principle (Mr. J. W. T. Walsh).

P_1 and P_2 are the two cells and e_1 and e_2 the two sources of potential the connected ends of which are of opposite polarity. The indicating instrument E is a sensitive electrometer. First, the values of e_1 and e_2 are adjusted by trial so that the dark currents through the cells (*i.e.* the currents passing when the cells are unilluminated) are balanced. The two sources of light to be compared are then placed so that each illuminates one cell, and their respective distances from the cells are adjusted until there is again no deflection on the electrometer. It has been found that the two cells obey the same law connecting current and illumination, so that once the constant of the apparatus has been determined it forms a ready means of comparing illuminations. In practice, differences of the order of 0.01 per cent. are said to be detectable, but it was to be presumed, he said, that an essential condition was that the light compared must be exactly of the same spectral distribution otherwise colour screens must be employed to render the sensitivity curves of the cells identical with that of the average eye. Such a screen had been devised by Dr. Voege and his work was described in the ILLUMINATING ENGINEER for June, 1914. He thought it might be said without fear of contradiction that in the case of the photo-electric cell, at least, comparison of two sources of light was all that was in any way practicable at present, and though it would be a distinct advance to be able to supplant the human eye by some physical apparatus, yet it would be a still greater boon if some means could be found of actually measuring illumination without the necessity of constant reference to some standard of comparison. Advance along these lines appeared more promising, he thought, in the case of the second class of physical photometers to which he had made reference above, viz., those in which the radiation from a source was measured by some instrument working generally on the principle of the thermopile. Dr. Ives, from whom they had had a most interesting communication that evening, was one of the pioneers in this field of physical photometry, and he was very interested to hear of the experiments progress being made, and of the results indicated. Mr. Dow had already given a very complete account of the methods and apparatus employed and there was therefore nothing for him to add as regards that portion of the subject. If he might be allowed another minute or two, however, he would like to ask the opinion of those present on a form of neutral filter for photometric use, the design of which had occurred to him some few months ago but which he had not had the opportunity of testing fully. It consisted of a piece of clear glass coated with an opaque dead black varnish. Fine lines were then scratched through the varnish thus baring the glass and presenting a transmitting area which might bear any desired ratio to the opaque, non-transmitting area. If these lines were carefully ruled the transmission coefficient would be even all over, and a very rough specimen he constructed hastily the other day gave a surprisingly even field when used in front of a Lummer-Brodhun photometer head. The lines were about ¾ mm. apart and the transmission coefficient came out to be in that case about 7 per cent. Such a device had very probably been employed before but as he had never seen an account of it, he thought it might be useful to mention it, because one of the problems which had given them considerable difficulty in illumination photometry at the N.P.L. had been the practical impossibility of obtaining a neutral filter glass. A similar device which had proved useful just lately in the reduction of very green illuminations was the use of successive thicknesses of black tulle. Each thickness was found to produce a reduction of approximately 9.3 per cent. and at 14 thicknesses the reduction was still sensibly the same, the transmission coefficient of this number of thicknesses being about 25 per cent. He should be very glad to know if such a form of filter had been used before. If so, no doubt someone present would have either seen an account of it or would have had first hand experience of its possibilities and limitations.

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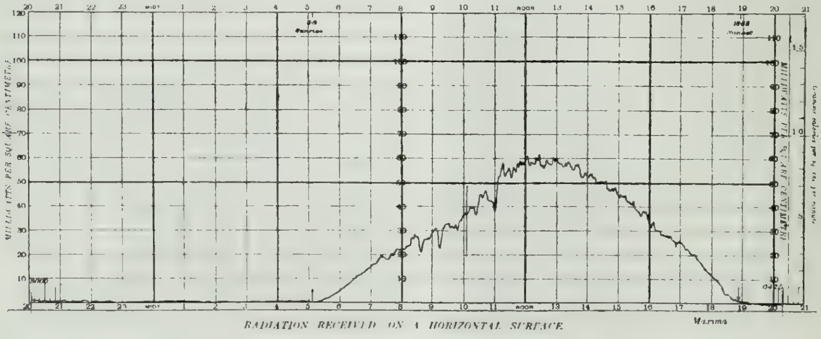
* F. K. Richtmyer, *Phys. Rev.*, 6, pp. 66–68. July, 1915.

Mr. F. J. W. **Whipple**, speaking upon Question 4, said that the instrument used more than any other for recording radiation in the meteorological service was the Campbell-Stokes sunshine recorder in which the light coming through a spherical lens browned a strip of blue cardboard and a record of the duration of sunshine was obtained. Of the instruments for measuring the direct intensity of the sunshine, the best known was the Angstrom apparatus in which there were two metallic strips, one of which was heated by sunshine and the other by a current passing through it. By means of a thermo-junction on the back any difference between the temperatures of these two strips was shown and the current was adjusted until the difference vanishes. This instrument had been given official sanction in more than one International Conference but it took a considerable time for each observation and was by no means portable. The portable apparatus which was most in favour for measuring the intensity of sunshine was Abbot's Silver Disc Pyrheliometer. Another instrument of a rather similar character was known as the Michelson Actinometer. In this there was a bi-metallic strip which was exposed to the illumination of the sun and then shut off from it. On the end of this bi-metallic strip was an aluminium arm carrying a quartz fibre, the movement of which was watched by means of a microscope and in this way the variation in the intensity of the sunshine could be measured with the utmost rapidity. It was practically a dead beat instrument. A steady reading could be obtained in 10 seconds which was remarkably quick for a purely mechanical device of this



Record of total radiation received during Saturday, August 29th, 1914, at the South Kensington Station (Mr. F. J. W. Whipple).

nature. An instrument which directly measured the heating effect of light from the sky as well as from the sun was the Callendar electrical recorder, and there should be no difficulty in making use of this instrument for practical illumination measurements. It could certainly be used for measuring the intensity of daylight illumination which he presumed came within the scope of the work of the Illuminating Engineering Society.

Mr. G. L. ADDENBROKE said that he had for some years carried out experiments on selenium as a dialectric.

The question of the effect of impurities was important. Twenty years ago he had made experiments on this point and had analysed the constitution of the impurities, amounting to about ½ per cent. These proved to consist partly of brass and partly of copper. The whole value of these cells lay in their preparation and, speaking generally, this must be regarded as an element of uncertainty. A great many people had spent time in preparing the cells in various ways, and found that their utility depended very much on this small impurity.

When it was remembered that a cell was frequently put on one side for long periods and then taken again into use, their conditions at the present stage did not appear very hopeful. The position seemed very similar to that which occurred in photography twenty-five years ago when many people were experimenting with the gelatine process. Many of these people were not chemists or scientific men, but by making a very large number of experiments, one out of the whole lot gave surprisingly good results, and this led to further progress.

He was much interested to hear of the work of Ives and others in the United States, and perhaps their work would eventually lead to a similar result.

Mr. W. R. COOPER said that the question referring to selenium appealed to him, but unfortunately it was not a very satisfactory substance to deal with. The sensitiveness of selenium did not correspond with that of the eye, for it was sensitive practically only to the orange part of the spectrum and consequently the effect produced by light varied with the wave-length. The sensitiveness also depended upon the heat treatment given to the selenium in preparing the resistance, the thickness of the selenium and the method of construction adopted. If selenium was used for photometric purposes it was necessary to calibrate the instrument, and it was quite impossible to compare sources of light differing in character; thus a source rich in red could not be compared with one deficient in red, except by means of special calibration. There were also other difficulties; the variation of resistance depended upon the length of exposure and complete recovery took a considerable time. Thus it was necessary to adopt a definite cycle in photometric work, the selenium being exposed for a short time and then allowed to recover for a certain time before another observation was taken. In looking over the literature on the subject he was struck with the fact that the amount of quantitative work carried out on the construction of selenium resistances was very little. Much more would have to be done in this direction before an idea could be obtained as to how a definite sensitiveness was obtained. Although there were objections to using selenium directly for photometric work it seemed to him that it might be used as a detector for comparing illuminations, and it would have the advantage of being free from fatigue which was troublesome to the eye. He could not agree with the opinion expressed by Mr. Addenbrooke that the action of selenium depended upon impurities. All the research for many years past was entirely against this view. With regard to the use of voltmeters on illumination photometers to check the constancy of the accumulators it should be remembered that a small voltmeter would not easily give a reading of one per cent. and that the variation of one per cent. in the voltage meant considerably more than one per cent. in the illumination.

Mr. L. GASTER (Hon. Secretary) expressed his appreciation of the interesting contributions to the discussion.

He thought the time was ripe for the invention of some simpler instruments for measuring illumination, which might permissibly be less accurate than the illumination photometers already available, but which would enable managers of works to tell at a glance the order of illumination prevailing in their factory.

The possibilities of selenium had always interested him, and he recalled that Dr. Ruhmer of Berlin had shown him, years ago, selenium cells which he stated were perfectly pure. He believed that the manner in which such selenium was prepared was of considerable consequence and had a distinct influence on the distribution of sensitiveness throughout the spectrum. It was of interest to recall that about twelve years ago a portable photometer using selenium was contrived by Dr. Torda. In this case the effect of fatigue due to continuous exposure to the illuminant was obviated by an automatic shutter which covered the cell after it had been exposed for a few seconds. This shutter was operated by clockwork and made it impossible to use the cell, except after a suitable interval for recovery.

In the course of his visits to factories he had been informed by the manager of one large factory that he had contrived a selenium apparatus to indicate, by the ringing of a bell, when the illumination fell below a specified value. Mr. Turner's apparatus seemed intended to accomplish the same result.

It had also occurred to him that an apparatus of this kind might possibly be contrived on the principle of the Dalen "sun-valve." This valve was employed with acetylene buoys and was constructed to turn off all but the bye-pass during the day, but to turn the cock full on at night, in this way leading to a very considerable saving in gas. The principle of the valve depended on the unequal expansion of two cylinders, one highly polished and one coated with dead black material. It was stated that in this way one secured an apparatus which responded to light rays but was practically unaffected by radiant heat.

In conclusion, Mr. Gaster referred to the interesting contributions describing the work being carried on in the United States on selenium and photo-electric cells, and thermopile measurements, and thanked the gentlemen concerned for the trouble they had taken in putting this information at the disposal of the meeting. No doubt this discussion would stimulate interest in the subject, and would, he hoped, lead to further advances in the measurement of light and illumination.

MR. J. S. DOW (*communicated*) :—It occurred to me that it would be of interest to describe two forms of photometers which were experimented with by Mr. Mackinney and myself some time ago, but, chiefly owing to the disturbance caused by the war, have not yet been developed to a practical stage.

One of these (see Fig. 1) may be termed a "cell-photometer," and is designed on very similar lines to that suggested by Mr. Cunnington. The lamp, in a dead-white chamber, produces an even illumination over a sheet of diffusing glass or celluloid. This surface becomes an illuminating source and illuminates a second white chamber. (This diffusing screen seems desirable in order to produce even illumination and diminish the light, but is not strictly necessary.) The even illumination in the upper white chamber lights up a second diffusing screen, which might be of flashed opal or ground glass. This is placed below a slab of white vulcanised fibre, in which a series of holes have been drilled. Above this slab a Leeson disc screen is arranged, the circular apertures being each above the corresponding hole. Thus each hole becomes an evenly illuminated cell lighting up the disc immediately above it. The intensity of the illumination in each hole can be graded by obscuring more or less of the translucent surface immediately under it. Thus we can arrange that a series of six small discs disappear at illumination of, say, 0.1, 0.5, 1, 2, 5, and 10 foot-candles. By having an exactly similar series of holes, but placing beneath them a suitable dark glass or strip of opal glass cutting off one-tenth of the light, we can secure an additional low scale with readings of 0.01, 0.05, 0.1, 0.2, 0.5 and 1 foot-candles.

Another way of meeting the problem is shown in Fig. 2. In this case the even illumination of a diffusing glass screen is again produced by a lamp in a white chamber. But the upper chamber is now black. It contains an opaque division running transversely across and dividing it in two so that, at the left top corner of the box the diffusing screen is entirely obscured, while at the right top corner it is entirely visible. As a result the illumination on the screen at the top falls uniformly from a prescribed value of illumination (say 10 foot-candles) to nothing.

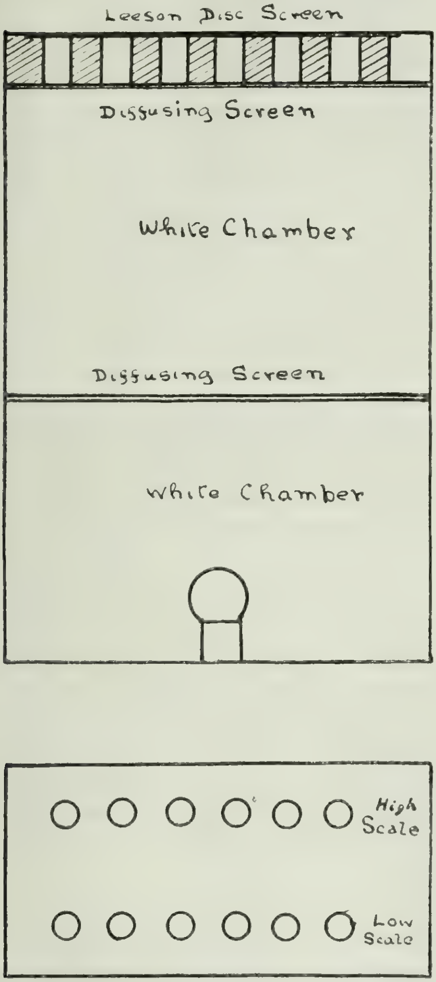


FIG. 1.—Scheme for portable illumination photometer of the "cell-type," requiring no manipulation to obtain a reading (Mr. J. S. Dow).

The screen is conveniently made on the Leeson principle. It may consist of a slot in a thin piece of cardboard, having on either side a thin sheet of tissue paper, and, as in the case of the other instrument, a lower scale of one-tenth the value could be obtained by placing suitable obscuring material under a second slot. The idea of this instrument was suggested to me by a simple apparatus shown at a meeting of the Society by Mr. Haydn T. Harrison some years ago.*

I found, however, that it is not easy to determine the precise point where the slot changes from "bright" to "dark"; the transition is too gradual. It therefore appears necessary in such instruments to have a series of discs or squares so that the surface to be judged is com-

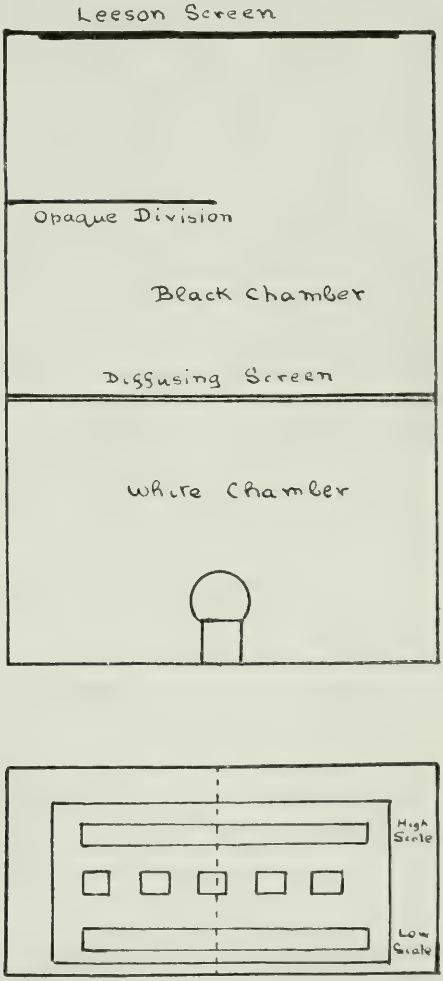


FIG. 2.—Scheme for portable illumination photometer, with graded scale requiring no manipulation (Mr. J. S. Dow).

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* *Illum. Eng.* Vol. III., 1910, p. 373.

pletely surrounded by the other one with which it is to be contrasted.

In both the instruments described above, one aims at obtaining a reading by mere inspection, and without having to manipulate anything to obtain a balance. In this way one approaches nearer to the principle of a direct reading electrical watt-meter, while an ordinary photometric instrument might be compared with a Siemens dynamometer.

As regards the question of making instruments of the "extinction" type, it is possible that such apparatus might furnish rough indications in cases where comparisons are made between lights of the same colour, or of the illumination yielded at various points by one and the same lamp. But in comparing sources which differ in spectrum composition it seems a wrong principle to take measurements at the extinction point where the eye is in an entirely different condition from what it is at ordinary illuminations. This matter deserves further study; it would probably be found that such methods favour unduly lights which have a pronounced green-blue element in their spectrum.

The observation of fine type introduces difficulties arising through variation in the acuteness of vision of the observer. Possibly such difficulties might be mitigated by employing *observation of contrast* which seems likely to vary to a less degree than *perception of form.*

The CHAIRMAN thought the subject of the discussion had been justified by the results. There had, he said, been some very interesting communications read and some most useful and valuable contributions from the speakers in the discussion. It seemed to him that we should realise very fully the necessity of having some reliable form or forms of portable photometers if we are to see the introduction of low illumination readings as the determining features regarding the performance or non-performance of street lighting contracts, and the compliance or non-compliance with statutory requirements in factories and workshops. We did not yet feel sufficiently certain that the portable photometers on the market could be relied upon with such a degree of accuracy within a small or reasonable margin of error as to provide the basis of a contract containing a penalty clause. At any rate he himself did not feel this and he did not think that many who were acquainted with the subject of illumination felt any certainty either. It had been quite truthfully said that it was impossible to carry the laboratory about in streets or in factories and it was necessary to be sure that results were obtained from portable instruments which closely approximated to laboratory tests. It was very good news to hear from Mr. Walsh that the National Physical Laboratory when war broke out were carrying out research in the direction of photometers depending on physical and chemical methods, but naturally they could not be expected to carry on this work during the war. Obviously the ideal was a physical and not a physiological determination of illumination, so that there could be no question of dispute through the introduction of the human error.

INDUSTRIAL ILLUMINATION.

We notice in the *Bulletino dell' Ufficio del Lavoro* (the official publication of the Italian Ministry of Agriculture, Industry and Commerce) a reference to the Report of the Home Office Departmental Committee on Lighting in Factories and Workshops in this country. The writer recalls the steps leading up to the issue of this Report, including the important place assigned to good industrial lighting at the Brussels Congress in 1910. The Italian Government have taken a prominent part in encouraging the research into industrial hygiene, and it is interesting to observe that they are fully informed as to the steps being taken in this direction in England.

NEW ADDRESS.

R. C. Bussell (Director of Blanchard British Lamps, Ltd.), 13, Haverstock Hill, London, N.W.

SUMMARY OF DISCUSSION.

For the convenience of members we give below a summary of the chief suggestions made in the course of the discussion printed *in extenso* in the preceding pages. The suggestions of the various speakers and contributors are arranged, as far as possible, under the heading of the respective inquiries (see p. 80) to which they refer.

(1) *What possible methods can you suggest for making illumination photometers of the ordinary type (i.e., those involving the use of a comparison source of light) more convenient for the use of the general public?*

Mr. Trotter (p. 84) expresses doubt whether "the general public" should be encouraged to amuse themselves with illumination photometers. Some experience is necessary. Mr. Cunnington, however (p. 89), thought that the difficulty of taking photometric observations is apt to be exaggerated and that simplification of the process might be encouraged. The Chairman (p. 100) pointed out the need for thoroughly reliable instruments for use in determining features regarding the performance or non-performance on contracts, especially those involving a penalty clause. For such work accurate apparatus was essential, even though this might involve some greater complexity.

Favourable experience with instruments of the luxometer and lumeter type is recorded. The chief source of difficulty is the fact of the battery gradually running down if the instrument is used for long periods. Dr. Marchant suggests that a device automatically correcting for change in voltage might be incorporated in the instrument (p. 85). Mr. W. R. Cooper (p. 97) pointed out that if a voltmeter were used, it should be exceptionally accurate. Mr. Cunnington did not find this difficulty of falling P.D. serious, but sometimes found it convenient to make a correction from a voltmeter reading. He thought, however, that such instruments should be simplified and that, for ordinary experimental work, no attempt should be made to make the user "independent of a laboratory," if this implied undue complexity.

One direction of experiment would be to produce instruments which could be read on inspection, without it being necessary to manipulate the parts to obtain balance. A form of "box-photometer" on this principle is described by Mr. Cunnington (p. 90) and other attempts in this direction are mentioned by Mr. Dow (p. 99). Mr. J. M. Trezise (p. 91) describes a new form of photometric screen, utilising a piece of white glass which is cut with a diamond and inclined at a suitable angle. This proves to be extremely sensitive. The screen has been embodied in various very compact forms of instruments, which are described. The apparatus can be compressed within very small dimensions by using a small lamp, placed very near to the illuminated screen.

Lieut. Haydn T. Harrison (p. 84) objects to the use of an eyepiece; the photometric screen should be viewed with both eyes. Mr. Walsh suggests a form of absorbing screen made by scratching fine lines on a glass coated with black varnish.

(2) *What are the prospects of making a satisfactory instrument depending on :—*

(*a*) *The principle of " extinction," i.e., diminishing the illumination to be measured until some small object just becomes invisible to the eye ?*

(*b*) *The observation of fine type—a minimum illumination being indicated by the fact of fine type becoming indistinguishable when viewed by the prevailing illumination at the point studied ?*

Mr. Trotter (p. 84) expresses the view that physiological difficulties render all methods of " extinction " and " minimum visible " misleading. Dr. Marchant (p. 85) thinks that instruments depending on acuteness of vision have very small prospect of accuracy. Lieut. Harrison (p. 85) does not favour measurements by observation of type, owing to variation in the acuteness of vision of observers. Instruments based on extinction can be contrived but the colour difficulty should be considered, and such instruments are probably only applicable when comparing lights of similar colour. The same view is expressed by Mr. Dow (p. 100), who adds that if such principles are used as a rough guide, observation of contrast would probably be preferable to perception of form. Mr. Cunnington (p. 91) has contrived an apparatus based on the latter principle, but so far has not got any reliable results.

(3) *What are the prospects of making a satisfactory instrument depending on the following physical or chemical methods :—*

(*a*) *The use of selenium or other photo-electric cells.*

(*b*) *The use of thermopiles or other instruments for measuring radiation with or without a suitable solution or screen for absorbing the non-visible rays.*

(*c*) *The difference in expansion of two metallic elements, one polished so as to reflect a maximum of visible light, the other coated with an absorbent mat black material, but otherwise similar.*

(*d*) *The use of photographic methods such as the darkening of light-sensitive paper.*

(*a*) Recent work on selenium and other photo-electric cells is summarised by Mr. Dow (pp. 81, 82) and by Mr. Walsh (p. 94). Reference is made to the effect of fatigue, the variations in the behaviour of different cells, and to the fact that the relative sensitiveness throughout the spectrum of selenium cells alters according to the illumination. Information on these points is also furnished by Mr. Cooper (p. 97).

Mr. Addenbrooke has found that impurities exercise an important influence on selenium (p. 97), but this is not Mr. Cooper's experience (p. 97). Selenium was used in a form of portable photometer by Torda many years ago, the instrument being provided with an automatic shutter to avoid the effect of fatigue (Mr. Gaster, p. 98). Mr. Turner has applied it to enable lamps to be automatically extinguished in daylight and lighted up in the evening, and it has been used in a similar purpose in factories (p. 98). Mr. Cooper also mentions the use of selenium cells as " detectors " in this way, but thinks that at present the various difficulties enumerated above prevent its successful use for photometry. However, improvements in the preparation of such cells may lead to an advance in the future.

The Elster and Geitel cell is described by Mr. Walsh (p. 94) and referred to by Prof. Féry (p. 88) and Dr. Ives (p. 87), who mentions some recent work having for its object the preparation of cells for which the relation between illumination and response is a straight-line law. Attempts are also being made to achieve uniformity as regards sensitiveness to light of different colours, in which case the photo-electric cell might prove a reliable and highly sensitive method of measurement. At present, however, it is essentially an apparatus for laboratory use.

(*b*) Mr. Dow describes recent instruments due to Ives for measuring light depending on the use of thermopiles (p. 83), and this subject is also discussed by Prof. Féry, who has evolved an apparatus of this type. Such instruments use either a cell of special solution to absorb the non-visible rays and correct the sensitiveness throughout the spectrum so as to produce what is equivalent to an " artificial eye" ; or a similar correction is applied by means of prisms and a suitable screen cutting down the radiation at each point in the spectrum in the desired proportion.

Still more recent experiments are described by Dr. Ives (p. 87) and Dr. Coblentz (p. 87).

It is hoped to increase the sensitiveness of such instruments by some form of current amplifier on the lines of those developed for wireless telegraphy.

Mr. Waldram (p. 85) points out the close resemblance between the curve of solar radiation obtained by physical instruments at the Meteorological Office and similar curves obtained with a photometer showing the variation in daylight throughout the day. Mr. Whipple reproduces a typical curve obtained by physical methods at South Kensington (p. 96) and describes a number of instruments used for measuring solar radiation ; these may have some application to photometric problems.

Experience seems to show that at present an instrument measuring radiation as heat, and corrected by prismatic means or by using a cell of special solution, affords the most accurate and hopeful method of measuring light by physical means. A high degree of accuracy has been obtained in the laboratory, but the refined nature of the apparatus and the small electric currents to be measured at present seem to impede the use of this method in portable illumination photometers. Moreover, in any case they involve the use of a battery, which is the chief difficulty in illumination photometers of the ordinary kind.

(*c*) A suggestion on this point is made by Mr. Gaster (p. 98) who remarks that the principle used in the Dalen solar valve for use with acetylene buoys might possibly be applied for the physical measurement of light. This apparatus depends on the unequal expansion of two elements, one highly polished and one coated a dead black, and is used for the automatic turning off of acetylene lights when in full daylight, the flame being turned on again when darkness falls. The application of the method to photometry requires further investigation.

(*d*) Photographic methods are referred to by various speakers (Mr. Dow, p. 82 ; Mr. Harrison, p. 85 ; Mr. Waldram, p. 85 ; Prof. Féry, p. 88).

It is pointed out that the relative sensitiveness throughout the spectrum differs considerably from that of the eye and varies according to the chemical material used. Therefore, while the method may be used for relative work, it is not readily applicable to the comparison of illuminants which differ in spectrum composition. Moreover, as a rule the use of photographic methods is tedious in comparison with the ease with which an ordinary illumination photometer can be handled. One special advantage of photography, however, is its integration of light-effects with respect to time. It may, therefore, have applications for testing fluctuating and very transient light-effects.

(4) *What instances can be quoted of the above principles being used successfully in other fields of photometry, for example, in records of daylight, meteorological observations, determining polar curves, observing fluctuations in the light given by various lamps, &c.?*

Lieut. Harrison refers to the use of photographic records of testing periodic fluctuations in the candlepower of flickering light-sources, and the deposits on the bulbs of incandescent electric lamps. The method has also been experimented with for tracing polar curves of light-sources. For this latter purpose thermopiles have also been used.

Photography has also been applied in dealing with very faint lights, for example in researches on the quality of light yielded by fireflies.

It is also suggested that some of the above methods, while not yet applicable to portable illumination photometers, would be of value in laboratory work on standards, &c., where minute changes in candlepower are being studied, and a check on personal observations by some method independent of physiological errors is therefore desirable.

(5) *Are you aware of any methods which could conveniently be employed in the design of instruments to indicate automatically when the illumination in an interior has fallen below a prescribed minimum, and an increase in the illumination is therefore necessary?*

Three cases are mentioned, the use of Turner's selenium apparatus for automatically extinguishing and lighting street lamps (p. 86); the use of selenium cells for indicating the time when artificial lighting is needed in factories (p. 98); and the use of the Dalen Sun Valve for automatic control of acetylene buoys. But little has been published regarding the accuracy with which such apparatus can be made to operate at a particular value of illumination

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RESEARCH ON PROBLEMS OF INTEREST TO THE LIGHTING INDUSTRY.

With a view to considering the organisation of research on problems of interest to the lighting industry, a Committee of the Illuminating Engineering Society has been formed, and will issue a Report on the subject for consideration at the Annual Meeting of the Society, to take place at the House of the Royal Society of Arts at 5 p.m. on Tuesday, May 9th This discussion will follow immediately after the conclusion of formal business.

Meantime members are invited to send in to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, S.W.) any suggestions for research which might profitably be supervised or undertaken by members of the Society, and these suggestions will be submitted to the Committee in due course.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

A Report presented by the Committee on Progress (Mr. F. E. Cady, *Chairman*, Mr. T. J. Litle, Mr. L. B. Marks, Mr. T. W. Rolph), at the Ninth Annual Convention of the Illuminating Engineering Society, held in Washington, September 20th to 23rd, 1915; slightly abbreviated.

(*Continued from Vol. VII.*, 1915, *p.* 450.)

The Panama-Pacific Exposition.

In its use of light the Panama-Pacific Exposition furnishes the most striking example of the progress of illuminating engineering that has ever been presented. It is an almost complete report in itself. For the first time in the history of such institutions a recognised illuminating engineer has been called in to take care of that branch of the work. For the first time in history the lighting of an International Exposition was completely designed and chartered before the buildings were erected, and the results bear eloquent testimony to the wisdom of that action. The latest types of street lighting both gas and electric are represented; the exteriors of the buildings are brilliant with "flood lighting"; the lighting of Festival Hall is a unique exampl of totally indirect lighting; display lighting is exemplified in the wonderful scintillator system and in the Tower of Jewels; efforts to avoid glare are manifest on all sides; never has there been a more lavish use of coloured light. And so this exposition stands as a living witness to the fact that illuminating engineering has "come into its own."

No attempt will be made to discuss all the novelties to be found in the lighting effects but reference will be made to some of the more prominent features of the illumination. More complete descriptions will be found by reference to the partial bibliography.[85] The basic idea back of the general illumination of the buildings was the desire to present the exposition at night in the same relative values of colour and perspective in which it is observed by day. On this account the old outline-system of illumination in which incandescent electric lamps were used to outline the architectural features of the buildings was abandoned in favour of the new flood-lighting idea and particular attention has been paid to the ocular comfort of the sightseer while at the same time displaying for his appreciation wonderful effects produced by artificial light.

Four principal methods of illumination are employed. Opposite the walls of the exhibit palaces are luminous art standards bearing transparent shields, through which light is thrown on to the fascades. A second method of illumination is found in the concealed batteries of searchlight projectors which are used to flood the monumental sculptures, towers and minarets so that the minutest architectural details are visible. A third source of lighting is that of the concealed light which proceeds from the inner recesses of the columns which encircle the courts or are placed on the lofty Tower of Jewels and the Italian Towers commanding the entrance to the Court of Palms and the Court of Flowers. This method of lighting is also used in the vaults of archways and in other situations where it is desired to cast light upon the mural paintings. The great battery of 48 searchlight projectors each with a 36-in. (91.44 cm.) lens forming the "scintillator" makes a fourth source of illumination.[86]

In addition to these four principal sources of lighting there are several minor sources. In various parts of the grounds are globes of white glass the light from which, at night, dissipates the shadows under the foliage. In the great central Court of the Universe two lofty columns of dense white glass are parts of the two fountains and are the principal source of the night illumination of the Court.

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[85] *Light. Jour.*, Mar., 1915, p. 49.
Elec. World, Feb. 13, 1915, p. 391.
Elec. World, May 29, 1915, p. 1383.

[86] *Sci. Amer.*, Apr. 24, 1915, p. 378.

The striking effect of the Tower of Jewels was obtained through the use of specially designed[87] jewels cut from glass obtained in Bohemia and having an index of refraction of from 1.68 to 1.71. Each gem is suspended so as to be free to swing with air currents and has a little mirror placed within one-sixteenth of an inch of the apex, thereby increasing the number of spectra obtainable.

A noteworthy feature of the highway lighting is the use of 18 to 24-in. (60.96 cm.) globes carrying glassware of an absorption of approximately 50 per cent. and of a warm opal tint approaching amber. The illumination of the interiors of the buildings is accomplished by the use of 250 and 500-watt tungsten lamps in specially designed mirror reflectors. The lamps are located from 40 to 100 ft. (12.19 to 30.48 m.) above the floor, the energy is less than 2 watts per square foot (9.29 sq. dm.) and the foot-candles range from ½ to ¾ on the floor.

The first commercial installation of high pressure gas lighting in this country[88] and one which is said to show many improvements over foreign practice is to be found in the State and Foreign Building Section. The main artery for traffic is the Avenue of Nations and this and other streets and avenues in this section are lighted by high pressure two-mantle lamps enclosed in opal globes mounted single on the top of ornamental staff work columns. The lamps consume 21 cu. ft. (5.94 m.^{3}) of gas per hour, operate at 3 pounds (1.36 kg.) pressure, reduced at the standard from 30 pounds, and have a mean spherical candlepower of 408.

Installations of the same lamps have been made at all the entrances and exits of the grounds. At the entrances and exits of the main group of exhibition palaces and at the entrances of the courts, lamps of the low pressure type are used, mounted on brackets. In the "Zone" gas standards 35 ft. (10.66 m.) high are placed at intervals of 100 ft. (30.48 m.) on both sides. There are 72 of these standards each carrying 5-mantle lamps with mercury valve distance control. Large decorative lanterns are hung about these lamps. Decorative effects[89] are obtained by the use of gas to produce tongues of flame from serpent-headed urns.

Some very spectacular effects are obtained[90] in the lighting of the glass dome of the Palace of Horticulture. These effects are made possible by the use of sets of specially designed lens plates, colour screens and high-powered searchlights. The system used in lighting the interior of Festival Hall is a separate and distinct type of interior lighting which is unique. In a pit beneath the centre of the floor are placed a number of searchlights which are set to throw their beams upward into a diffusing disk of thick glass sand-blasted on the under side, which distributes the light over the dome covering the auditorium and the dome in turn acts as a diffusing reflector.

The most bizarre and spectacular phenomena are produced by the "scintallator," over 300 effects having been worked out.

At the San Diego Exposition[91] neither the "flood-lighting" nor the "outline" system of illumination is used, but ordinary street lighting supplemented by light from the arches of the arcades. This has been found very satisfactory.

(*To be continued.*)

SUBMARINE SEARCHLIGHTS.

A recent issue of *Popular Mechanics* contains several articles describing special applications for searchlights during the war.

The first of these describes a method, developed by an American, to locate submerged mines. A powerful enclosed searchlight is mounted under water to one side of the vessel and near the bow. Slightly above the searchlight there is a periscope mirror arrangement, enclosed in a tube coming up to the deck, through which, it is claimed, the observer can see any object illuminated by the searchlight beam at a distance as great as 2,000 feet,

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[87] *N. E. L. A. Bul.*, Apr., 1915, p. 250.

[88] *Amer.Gas Light. Jour.*, Nov. 30, 1914, p. 349. *Jour. of Gas Light.*, July 6, 1915, p. 17.

[89] *Gas Inst. News*, Aug., 1915, p. 343.

[90] *Elec. Rev. and W. E.*, June 5, 1915, p. 1032. *Sci. Amer.*, Feb. 20, 1915, p. 180.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

BRITISH-MADE GLASSWARE.

DISPLAY AT THE BRITISH INDUSTRIES FAIR, SOUTH KENSINGTON.

At the British Industries Fair, held at the Victoria and Albert Museum, South Kensington, from February 21st—March 3rd, the exhibits included an interesting display of British-made glassware and pottery. Much of this was of an ornamental type of table use, cut-glass vessels being a specially well-represented section.

We were, however, also interested to notice the number of firms that are now supplying British-made glassware for lighting, as well as special glass vessels for scientific and chemical work. Among the suppliers of laboratory glass we note the names of the Edinburgh and Leith Flint Glass Co., Messrs. Molineaux, Webb & Co., Ltd. (Ancoats, Manchester) and John Moncrieff, Ltd. (Perth), while the section on lighting glass included exhibits from the following:—Messrs. A. M. Allan & Co. (Glasgow), Messrs. Burtles, Tate & Co. (Manchester), Messrs. A. & J. Davies, Ltd. (Stourbridge), the Edinburgh and Leith Flint Glass Co. (Edinburgh), "Glass Sundries" (London), Messrs. Greener & Co. (Sunderland), Messrs. Molineaux, Webb & Co., Ltd. (Ancoats, Manchester), and the New English Glass Manufacturers, Ltd. (Tipton).

The show of lighting glass was not very extensive in comparison with the large space devoted to domestic and table ware, but we were glad to notice several examples of special fancy shades, the manufacture of which had only been undertaken since the war. Another section of some interest was the manufacture of pavement lights and prismatic glassware for the direction of daylight in confined areas.

"LAMLOK" SPECIALITIES.

The Edison and Swan United Electric Light Co., Ltd., send us particulars of the "Lamlok" lamp locking lampholder. This holder can only be unlocked by the proper key, and thus gives the person in authority the complete control over all lamps on his circuit.

Such holders are of considerable utility in large installations in preventing unauthorised removal of lamps or substitution for existing lamps of others of an incorrect candlepower.

We have also to acknowledge the receipt of the latest show-card of the Company, bearing a cardboard representation of a man's arm carrying a Royal Ediswan lamp at arm's length.

ROBERTSON LAMPS.

A recent list of Robertson lamps contains particulars of many miniature and special patterns, candle lamps, &c. We notice particularly the tubular heating lamps having a special doubled and centrally supported filament, designed to secure even distribution of heat all over the bulb and therefore satisfactory life.

The leaflet also contains a view of the Glass Works, Lemington-on-Tyne, and various views of lamp-making operations at the Osram-Robertson Lamp Works.

"OSRAM" RELIABILITY.

The General Electric Co., of China, Ltd., Shanghai, report that they have for the sixth time been successful in securing the yearly contract for the supply of Osram Traction type lamps to the Shanghai Tramways. This contract was secured in face of competition from the suppliers of many other makes of lamps.

HOLOPHANE ELECTRIC LIGHT FITTINGS.

At the present time the manufacture of glassware for the lighting industry is receiving a considerable amount of attention in this country. On the outbreak of war it became apparent that we were dependent to a great extent on supplies from abroad. It is therefore gratifying to note that Holophane glassware, even before the war, was manufactured in this country, and we understand that since the war there has naturally been great activity with this work, some important new varieties—notably the metal-protected industrial units—being introduced.

However, the supply of suitable fixtures for such glassware is also important, and we have before us a recently issued catalogue of Holophane Fittings which deserves attention. The catalogue is excellently illustrated and contains a number of pleasing examples of fittings in various styles. Holophane glassware lends itself particularly well to use with somewhat massive fittings of an imposing type, and the bowl form is specially well adapted to ceiling units. The example shown on the opposite page illustrates a type in which the central bowl is combined with a series of pendant reflectors—a striking form of unit that deserves to be widely known. Presumably by a combination of this kind one could get effects as regards distribution of light that might not otherwise be easily obtained. Another illustration shows a typical hanging unit of the Excellite type for use with half-watt lamps, while the two-lamp bracket fitting shown in Fig. 3 is a pleasing form of unit for general lighting.

We may also mention the series of semi-indirect fittings for dining-room lighting. Amongst these we notice a type in which the semi-indirect unit is combined with pendant reflectors, thus giving at the same time a good general illumination and the requisite local lighting over the table. This seems a good way of meeting the special requirements of a large dining-room.

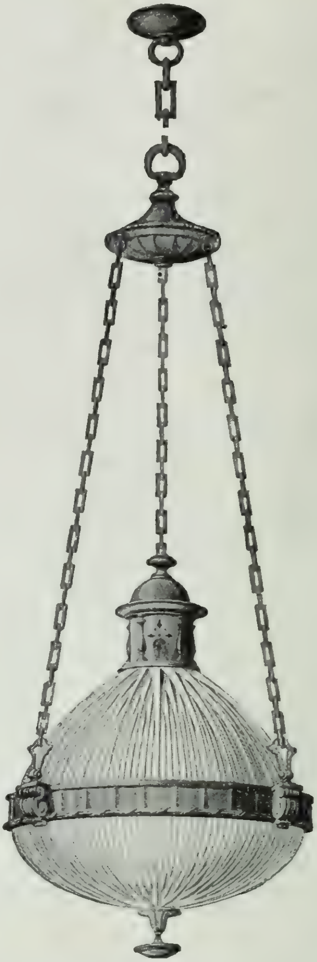

FIG. 1.—Holophane Excellite Pendant for Half-watt Lamps.

The semi-indirect bowl is in itself a pleasing object. But for those who admire illuminated silk shades it is worth noting that this unit can conveniently be screened by a silk canopy below. In this way the decorative effect of the silk is obtained and at the same time, owing to the fact that a great percentage of the light is reflected upwards, the loss of light is relatively small.

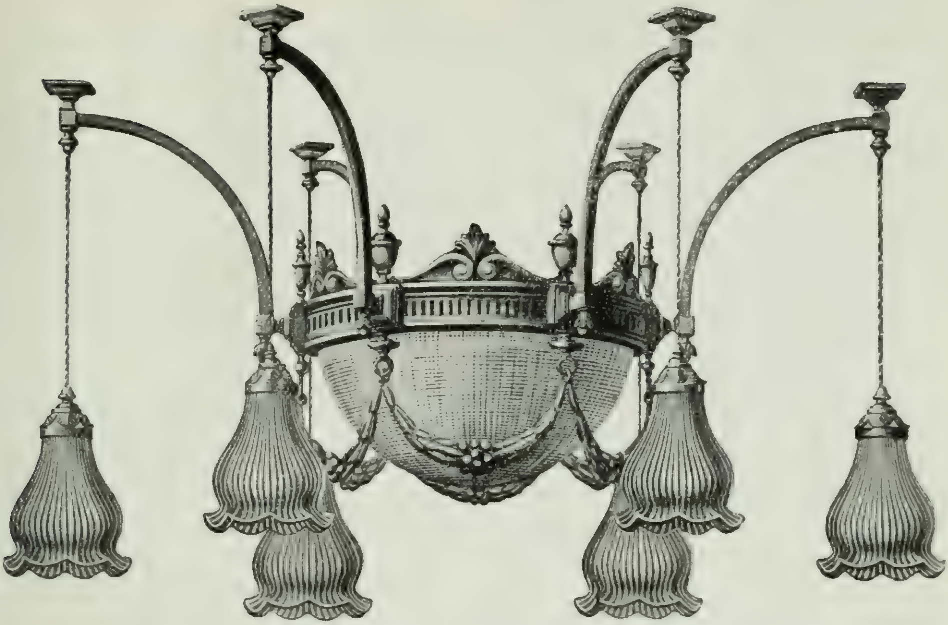

FIG. 2.—Holophane combined 16-inch stiletto bowl ceiling fitting with six reflectors.

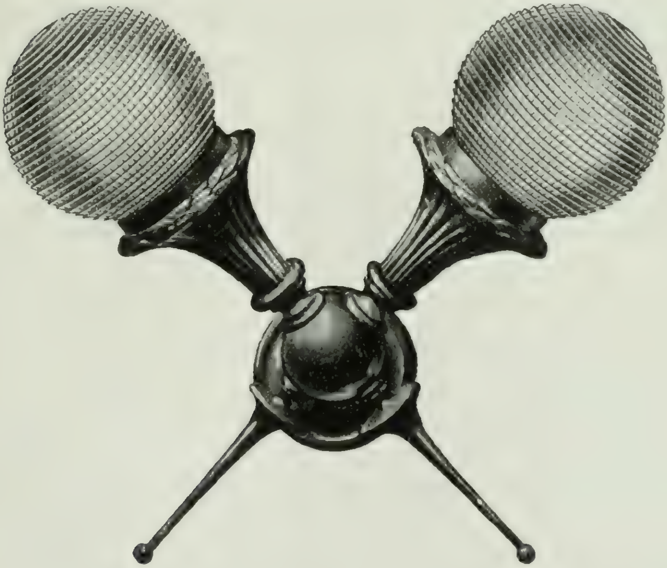

FIG. 3.—Two-light bracket with Holophane globes.

Typical Holophane Electric Light Fittings for Interior Lighting.

INFORMATION ON INDUSTRIAL LIGHTING.

In view of the special attention given to this subject in our last issue, readers may be interested to refer to the special section which forms a feature of the *Electrical Engineer's Diary* (S. Davis and Co., St. Swithin's Lane, E.C.) for 1916, which was recently noticed in these columns.

Several of the aspects of factory lighting touched upon in our last number are fully treated in this special section, and we would draw particular attention to the tabulated list of requirements of various trades. Not only are the operations roughly classified as regards the amount of illumination needed, but suggestions are made for the correct spacing of lamps, the choice of local or general lighting, &c. In addition, hints are given as to the special problems to be met as regards discrimination of colour-values, correct shadow conditions, maintenance and cleaning. This last point is an exceedingly important one in many industrial installations, and it is worth noting that the loss of light occasioned by a few weeks' neglect may work out as high as 40 per cent. The money-value of the loss of illumination is frequently considerable in comparison with the cost of periodical cleaning.

GLARE AND THE STUDENT'S LIFE.

A recent article on this subject by Dr. James Kerr in *School Hygiene* draws attention to many points that have been studied by the Illuminating Engineering Societies in this country and in the United States. Dr. Kerr points out how visual acuity is readily affected by the glare from unshaded light sources, six distinct physiological effects being distinguished. He advocates that "*no naked filament, mantle or flame should be permitted, nor any source of light with greater intrinsic brilliancy than three candles per square inch.*"

In addition, the glare from highly-glazed and polished surfaces is apt to give trouble, and for school-books paper with a dull surface is strongly recommended. Dr. Kerr also refers to the need for establishing a standard of glare and mentions the instrument devised by Mr. A. P. Trotter for testing the qualities of different varieties of paper in this respect.

USE OF UNGLAZED PAPER FOR ILLUSTRATED BOOKLETS.

We are glad to notice that the *Edison Monthly* is now to be included in the list of journals printed on mat paper. As usual recent numbers of the *Bulletin* are well illustrated, and quite good effects are obtained from half-tone blocks.

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(Founded in London, 1909)

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This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

A LIGHT-SCREEN FOR USE IN WAR TIME.

We notice that a new form of screen for use with lamps in war time has been introduced by Messrs. Falk, Stadelmann & Co., Ltd. This "Diffusa" screen, we understand, consists of three conical metal rings placed one above the other with a view to obstructing the passage of light upwards in the manner required by the present circumstances and yet avoiding the production of bright spots of light below. The screen is applicable to outside lamps in streets, yards, &c. and can be used either with upright or inverted burners.

BRITISH COMMERCIAL GAS ASSOCIATION.

FOURTH ANNUAL REPORT.

The Fourth Annual Report of the British Commercial Gas Association has recently been issued. In view of the short time that the Association has been established its activity has surely been extraordinary, and its work furnishes one of the most remarkable examples of co-operative effort during recent years.

It is stated that the Association now embraces over 80 per cent. of the annual output of gas in the British Isles. Since the outbreak of war an enterprising policy of continuity of work has been adopted, and in many respects this work has been of real educational value. A special instance is furnished by the publicity given to the Home Office Report on Factory Lighting, the opportunity being taken to impress on all and sundry the benefits of good industrial lighting. As a result this valuable report has been made known to many people who would perhaps not otherwise have given it attention, and a stimulus has been given to the study of lighting in many factories which are working overtime on Government contracts and where, therefore, good illumination is of great importance at the present time

ANOTHER LARGE GAS-LIGHTED BUILDING IN THE UNITED STATES.

In our last issue we mentioned the Woolworth Building in New York, as a good example of a large interior lighted by gas on up-to-date lines.

We notice in *The Gas Age* for February 15th an interesting account of the lighting of the New Offices of the Consolidated Gas Co. (also in New York), which is interested both in gas and electric lighting. The illumination of the building is illustrative of this dual interest. The exterior is lighted lavishly by studded electric incandescent lamps, while the chief offices inside are illuminated with gas semi-indirect units, the fittings being of a massive and highly decorative character. Sixteen-inch and 24-inch bowls are largely employed, the latter containing two 5-mantle horizontal burners. The overall length of the fixture is 5 ft. 5 in., and the diffusing glass is selected to give a soft amber effect.

Another interesting point is the control of these gas units by electric ignition, the cock being opened and shut by an electro-magnetic apparatus and the gas ignited by a heated wire.

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by
LEON GASTER

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EDITORIAL.

Illuminating Glassware.

The properties of glass, in the form of globes, shades and reflectors, window panes, lenses and mirrors, absorbing screens and coloured media, &c., fall naturally within the scope of the Illuminating Engineering Society, and the discussion on the subject at the last meeting of the Society on March 21st brought out many interesting points.

Since the outbreak of war we have come to recognise the dependence of this country on foreign manufacture for many essential glass articles especially those required for chemical and optical work. There have been similar difficulties in regard to illuminating glassware, such as the lack of satisfactory heat-resisting glass for globes and chimneys used with incandescent gas and oil lamps, electric arc lamps and other high temperature sources. Some manufacturers have made considerable progress towards the supply of such articles but the difficulties, partly industrial and economic and partly scientific, must not be underrated, and it is evident that if the lost ground is to be regained a very complete study of the whole industry will have to be made.

While a detailed study of the industrial aspects of the problem hardly fall within our scope it is needful to remember that these considerations modify to a great extent many conclusions that might be reached on purely scientific grounds. Experience shows that in most sections of the glass industry there is no great difficulty in securing the proper materials. There is doubtless room for study of the correct composition of glass for various purposes and here the chemist can do excellent work. But when formulae have been obtained there remains the question of the practical working of the material and here the human element plays an essential part. While in some branches of glass manufacture proper appliances and machinery are the chief necessity, in others the skill of the individual operator is the determining element. In attacking new sections of the glass trade, therefore, the need of a supply of trained men for the time being imposes a limitation. It is also recognised that in most cases the cost of labour forms a very substantial part of the total cost of production; cheapness can therefore only be attained by producing on a large scale and the manufacturer is dependent to a very great extent on the expertness and goodwill of the operator.

A great deal has been said regarding the limitation of output and other labour difficulties. While there has doubtless been misguided action in this respect it is necessary to bear in mind the exacting nature of the work. The unsatisfactory conditions in some glassworks can only be remedied by a sympathetic consideration of the matter from the worker's standpoint and by educational measures which will both raise the skill of the worker to a higher level and enable him to get a clearer grasp of the factors on which the prosperity both of master and man ultimately depends.

We have touched upon the above matters in order to show that the regeneration of the glass industry is not a matter of scientific research alone, but of co-operative effort on the part of scientists and those actually engaged in the industry. The need for scientific method and research is, however, generally acknowledged and the discussion at the last meeting of the Illuminating Engineering Society on "Some Aspects of the Design and Use of Glassware in relation to Natural and Artificial Illumination," was very timely. The Society was privileged to hear the views of two members of the Glass Research Committee of the Institution of Chemistry. This Committee has already done most useful work in determining the composition of various kinds of glass required in chemical, laboratory, and other special work and there appear to be opportunities for useful work in the extension of these researches to include certain varieties of illuminating glassware.

There are many varieties of glass needed in the lighting industry which deserve further study such as heat-resisting glassware for globes, chimneys, &c., diffusing white glass for globes, shades and reflectors, and screens of standard absorbing power or of special colour such as are required for scientific work. The study of this question involves the devising of tests and definitions which will prescribe, with reasonable latitude, what the illuminating engineer requires ; and the examination, with the co-operation of manufacturers, of our existing facilities for the production of such glassware.

Another point, of great importance from the manufacturer's standpoint, is the possibility of effecting greater uniformity in commonly used glass articles. All must agree as to the desirability of avoiding forms of standardisation which would tend to restrict progress, or set bounds to the elasticity of design required to meet individual tastes. But there appear to be many kinds of widely used articles, such as plain globes, electric lamp-bulbs, &c., where the immense variations in the nature and dimensions appear to arise from caprice and the lack of effective co-operation rather than any condition in the industry. In such cases agreement on tentative uniform standards might be very beneficial both to users and manufacturers and proposals to this effect would doubtless be sympathetically considered by the large gas and electric supply companies, Government departments, and municipalities.

Regarded as a whole the glass industry certainly offers a field for useful inquiry. We do not underrate the difficulties of embarking upon new methods of manufacture and changing old established usage, but the present is surely the right time to take stock of the situation and see where we stand. On investigation it would probably be found that some kinds of glass are manufactured abroad for reasons which make it impracticable to do the same kind of work in this country. In other cases it might be found that existing difficulties could be overcome in course of time and with favourable results for the future. In other cases, again, it might be shown that although the prospect of making glass on a large scale was not very hopeful, yet the particular varieties under consideration were so essential in the national interest that it would be well worth while to establish a source of supply which could always be relied upon in time of need. Many of the varieties of optical glass, which have been so difficult to obtain since the outbreak of war, would fall within this category.

One thing at least seems to be well established—that the scientific study of the properties of glass has not received the attention that it deserves in this country, and it was this consideration which doubtless led Dr. Glazebrook, when presiding at a recent meeting at the Royal Society of Arts, to urge the necessity of establishing in London a central Optical Institute for the prosecution of such researches.

It has been agreed that the Illuminating Engineering Society shall appoint a Committee to consider the various problems raised in this discussion. The Committee will, we hope, be instrumental in bringing about co-operation in connection with this neglected subject of illuminating glassware and in initiating some useful researches.

Co-operation in Scientific Research.

In our last number we discussed the promotion of unity of effort on the part of the various bodies now engaged in studying the organisation of scientific and industrial research. This question was brought up at a recent meeting called by the Royal Society, at which many influential scientific and technical societies were represented. A Resolution was passed unanimously advocating the formation of a Conjoint Board of Scientific Societies with a view to promoting the co-operation of those interested in pure or applied science. It may be hoped that in due course the assistance of all the scientific and technical societies throughout the country will be secured, so that any question that arises may be allocated to the body which has made a special study of the subject to be considered.

There can be do doubt that some form of central organisation is needed. In many cases valuable work, deserving of being much more widely known, is being carried on ; yet such work may pass almost unnoticed outside the transactions of the Society concerned. The same applies to many Colleges and Institutions now engaged in Research work, and we notice that a letter on this subject has been contributed by Dr. A. E. Kennelly, of the Massachusetts Institute of Technology, to the Journal of the Franklin Institute (U.S.A.). Dr. Kennelly points out that there are many laboratories in the States working on independent lines, each, as a rule, conducting researches as though it were the only laboratory in the country, and therefore unaware of researches of a similar character that may be going on simultaneously at other Institutions. It would clearly be a gain if such laboratories could be co-ordinated without interfering with their individual initiative, and it is suggested that the Franklin Institute might take the lead in bringing about unity of effort. The Institute might, for example, give fuller publicity to the researches now being conducted, suggest subjects of research, offer grants to the laboratories best suited for them, invite suggestions from industries, and encourage mutual understanding between the laboratories.

In this country a similar state of affairs exists and it would be very helpful if some body could act in the way suggested above.

The question of organising suitable publicity for such researches should be studied by a central body in a position to determine when the results of research can be given freely to the public, and when their military or naval bearing, or their peculiar industrial value renders it necessary either to withhold such information or to present it in a very general form.

In any case it is clearly desirable that the existence of all such experiments should be recorded, in order to furnish a central source of information to which those who are entitled to receive details can gain access.

In cases where full publicity is desirable the co-operation of the scientific and technical press should be freely sought. Its value in this connection was pointed out in our last number when we referred to the discussion at the last meeting of the Circle of Scientific and Technical Journalists on March 14th, and it would clearly have a salutary influence if the various schemes for organising scientific research could be fully discussed by that body. The efforts being made in this direction by various associations should lead to useful results but it is most desirable that their aims should be widely known and discussed in order that any tendency to conflicting action and overlapping of effort may be recognised and avoided at an early stage.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

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SOME ASPECTS OF THE DESIGN AND USE OF GLASSWARE IN RELATION TO NATURAL AND ARTIFICIAL ILLUMINATION.

Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, London, at 5 p.m., on Tuesday, March 21st, 1916.

A Meeting of the Society took place as stated above, on Tuesday, March 21st, Mr. F. W. GOODENOUGH being in the Chair.

The Minutes of the last meeting having been taken as read the names of the following new applicants for membership were announced :—

Dobbins, Ed.	The Maximum Co., Ltd., 28 Victoria Street, LONDON, W.
Lancaster, E. W.	Holophane Ltd., 12, Carteret Street, Queen Anne's Gate, LONDON.

The Chairman then called upon Mr. S. B. LANGLANDS to read his paper, entitled, "Some Aspects of the Design and Use of Glassware in Relation to Natural and Artificial Illumination," and an interesting discussion took place, in which Mr. BERTRAM BLUNT, F.I.C., and Mr. W. C. HANCOCK, F.I.C. (members of the Glass Research Committee of the Institute of Chemistry), Mr. E. STROUD, Mr. A. P. TROTTER, Dr. M. W. TRAVERS, Mr. J. S. DOW, Mr. O. P. MACFARLANE, Mr. L. GASTER, Mr. W. M. MASON, Mr. R. W. HOOD, Mr. G. CAMPBELL, Mr. E. BARTON, and Mr. G. HERBERT took part.

Written communications from Mr. W. C. CLINTON, Messrs. STEVENS & WILLIAMS, Alderman R. BURTLES and Mr. ED. DOBBINS were also presented by the ASST. HON. SECRETARY.

Mr. S. B. LANGLANDS briefly replied, and a vote of thanks to the Author concluded the proceedings.

In conclusion, the CHAIRMAN announced that the **Annual Meeting** would take place at **5 p.m.**, on **Tuesday, May 9th.** After the conclusion of formal business there would be a discussion on the **Report** to be presented by the **Research Committee** of the Society.

SOME ASPECTS OF THE DESIGN AND USE OF GLASS WARE IN RELATION TO NATURAL AND ARTIFICIAL ILLUMINATION.

By S. B. LANGLANDS (Inspector of Lighting to the Corporation of Glasgow).

(Introduction to a Discussion at a Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, March 21st, 1916.)

MY object in these introductory remarks is to show the wide scope for study in relation to glassware for illuminating purposes, and to discuss a few of the problems that come within the scope of the Illuminating Engineering Society. At the present stage it is hardly possible to give much definite information as to what is being done. In the past, as is well known, we have been dependent to a very large extent on imported glassware. With the outbreak of war we came to realise more fully our dependent position, and steps are already being taken to improve our facilities in this respect. We are thus in a transition position. What I would like especially to bring home is that glass manufacture is essentially an industry which demands scientific treatment, and that the problems involved can only be effectually solved by co-operation between those interested in all the various uses of glassware for lighting.

I do not propose to enter deeply into the wider industrial problems, such as the attitude of the Trades Unions, the protection of home industries, &c., which are acutely illustrated in the glass industry. For the moment our duty is to study the scientific and technical aspects.

Being a material for the direction of rays of light, glass is naturally of interest to illuminating engineers who are concerned with the practical applications of light. Some of the members of the Society are interested in the design and use of optical instruments, and most of them come in contact with optical problems in which glass plays an important part. Last year a meeting of the Society was devoted to the discussion of searchlights, and in the past there have been discussions of globes and reflectors and of photometric instruments in which lenses and mirrors are used. The question of most immediate interest to us, however, is the use of glass in natural and artificial lighting.

For natural illumination the manufacture of prismatic glass for distributing the light in more or less obstructed interiors is of interest; even the manufacture of ordinary window glass, serving for the admission of daylight, has its problems. For artificial lighting we have the manufacture of electric lamp-bulbs, chimneys for gas and oil lamps, and globes and reflectors for all illuminants.

At the outbreak of war there were great inconveniences in this latter branch, particularly in respect of the so-called "heat-resisting" glassware. Much of the glass of this kind was made at Jena, and manufacturers in this country have already undertaken the production of glassware for use with high-pressure and other lamps, in which a considerable amount of heat is developed. Glassware for globes and chimneys has to fulfil a number of requirements. It must be (*a*) suitable transparent, (*b*) colourless, (*c*) capable of withstanding heat, and (*d*) must be durable and must retain its transparency in use.

Some years ago I made rigid practical tests of different varieties of glass for a certain burner, with the following results:—

(A) A German glass.—First for durability, but bad for fogging.

(B) A German glass.—Second for durability, and better as regards fogging.

(C) Jena glass.—Third for durability but no fogging.

(D) British glass.—Fourth for durability, unequal in composition; sometimes fogged and sometimes did not.

(E) American glass.—Fifth for durability. No fogging.

I mention this test because it showed a weakness in the British glass, lack of uniformity which is essentially a defect that implies want of scientific supervision. The remarkable success of the Jena works,* State-aided in their infancy, is doubtless due largely to the consistency of the material supplied, the ability to manufacture a glass with given chemical and physical properties again and again. Fogging is ascribed to the presence of lead in the glass. Jena glass contains no lead. It is a fact that since the war began a number of British glass works have undertaken the manufacture of improved glass in this respect. But if this progress is to continue it is essential that the qualities and composition of glass should become standardised on scientific lines, thus forming a groundwork on which we can build for the future.

In addition to the question of standardisation of material, there seems an opening for standardisation in regard to dimensions of glass implements.

Those who have had to do with the lighting of large numbers of buildings know how inconvenient and unnecessary are the great diversities in the size of lamp-bulbs, chimneys, globes, &c. As one who has to do both with gas and electric lighting on a large scale—Glasgow is, perhaps, the biggest lighting authority in the Kingdom—I have often been struck by this fact, and I would suggest that this Society, representing so many sections of the lighting industry, is in a particularly happy position to tackle the problem. Standardisation in this respect would not only simplify greatly the manufacture of glassware for lighting purposes, but would also prove a convenience to consumers. If possible the variety of sizes of glassware should be diminished, and a definite series of units in ascending units agreed upon. The sizes selected for globes would naturally depend to a great extent on the candle-power of the lamps for which they are intended. In the case of globes for softening and diminishing the light the size would depend on the limitation of temperature and the maintenance of the intrinsic brilliancy of the unit within a convenient value. Probably it would also be affected by aesthetic considerations as the size of a unit should presumably bear some relation to the size of the interior in which it is used.

Another point on which information would be of interest is the success with which makers in this country have undertaken the production of pressed glass globes in the larger sizes. I understand that the Holophane prismatic glassware was established in this country previous to the war, but it is common knowledge that many of the large white glass units of a decorative kind were imported from abroad, and it is surely up to us to produce good work of this kind in this country.

The question of standardisation of material applies also to hemispheres and globes of a diffusing kind. It is well known that the qualities of white glass available differ very much. In some cases, flashed opal for example, uniform illumination over the entire surface is readily obtained and the filament or mantle is entirely obscured; in other cases, pot opal for example, one can still see the source through the glass and the diffusion is not so good. It is therefore of interest, from the lighting standpoint, to specify exactly the quality of the glass so as to secure the requisite uniformity of diffusion, combined with minimum absorption.

Similarly, the colour and permanence of such glasses need to be specified. One finds that some varieties of so-called white glass are apt to become tinged with yellow, and that sometimes an uneven density is produced. Such defects will not be found in the finest glassware. Again, in the case of the larger units the *weight* of the glass is not without significance. In view of the tendency towards the production of sources of high candle-power, this element may have an appreciable effect on the question of fixture-design.

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* I would refer those interested to the work by Hovestadt on "Jena Glass: Scientific and Industrial Application." Translated by J. D. and A. Everett.

The need for standard dimensions is equally important in the case of reflectors. It is particularly important to check, as far as possible, the tendency on the part of the public to use lamps with reflectors for which they are totally unsuited. Many of the existing reflectors designed originally for carbon filament lamps, for example, are quite unsuited to the metal filament lamps and still more the "half-watt" lamps.

Another matter requiring the supervision of the Illuminating Engineering Society is the testing of the absorption of glasses and of globes and reflectors composed of various kinds of glass. One finds that there are great differences of opinion regarding the amount of light absorbed by different kinds of glassware, and the uncertainty on this point is intensified by the fact that it is possible to get two varieties of glass which appear very similar to the eye but differ widely in respect of absorption. This again, is particularly true of white glass the constitution of which is conveniently analysed under the microscope. In this way differences in quality may be revealed which would escape the naked eye, and differences in diffusing power may be explained.

In regard to reflectors the "reflecting power" is still further complicated by the differences in the percentage of the total light-flux enclosed by the reflector. Obviously a very shallow reflector, which only intercepts a very small portion of the rays of light, would have an apparently high reflecting power; but, nevertheless, it might entirely fail to comply with the requirements of a good reflector as regards screening the light source from the eye and promoting the proper distribution of light. It would appear, therefore, that when mentioning the amount of light reflected by a unit, some statement as to the percentage of the light flux enclosed is also called for.

Tests of the absorbing power of globes and reflectors immediately introduce photometric problems, and call for the services of the illuminating engineer. The preparation of a series of samples of typical glass accompanied by data as regards composition, colour, and absorbing power would be of great value. In regard to fancy coloured shades, the testing of colour is of some importance, and even more so in the case of coloured glasses manufactured for certain specific purposes (*e.g.*, for signal glasses). Accurate tests of such glass require the use of the spectrophotometer, and there are other means, which have been discussed before the Society, of studying such problems. It appears, however, that there is a need for some very simple form of colour-analysing apparatus, and the Society, which has done so much to simplify measurements of the intensity of illumination, might also devote its efforts towards the production of simple instruments for colour-analysis.

Such investigations are also of importance in studying the want of permanence in the colour of glasses and the explanation of fading.

An allied problem for the Society to consider is the production of glasses excluding rays of light which are deleterious for certain classes of work. There has been much discussion of recent years regarding the influence of the ultra-violet rays on eyesight. Whatever be their influence in this respect, it seems to be well established that such rays have a considerable effect in causing the fading of colours of pictures and fabrics. I believe that a glass has been produced in this country capable of absorbing such rays, and therefore suitable for use in glass cases intended to contain valuable coloured objects for exhibition. This point is of special interest to lighting engineers because of the discussion that has taken place regarding the effect of artificial light on coloured materials. There seems good ground for thinking that, however artificial illuminants may differ in this respect, the majority of illuminants, as used for ordinary purposes of illumination, are much less likely to cause fading than prolonged exposure to daylight. But in special cases it might be desirable to include lamps in globes made of a variety of glass which checks the ultra-violet rays but allows the visible rays to pass unimpeded.

Yet another interesting problem is the production of tinted glass for use with artificial illuminants to produce "artificial daylight." Bulbs for incandescent electric lamps have recently been made of such material, and screens for use with incandescent gaslight have also been developed. The problem is of considerable interest to industries where correct colour-matching is essential, and it would be very desirable to have glass for this purpose accurately analysed and specified for different types of lamps.

Finally there are many problems that arise in connection with the making of optical instruments which are also of importance in photometry; and conversely there are many optical problems in which convenient methods of measuring light are of great assistance. Experts on photometry could often furnish a hint to those engaged in optical problems. One question which has doubtless often forced itself before the notice of photometric workers is the production of neutral glass of standard absorbing power. There has been no difficulty in obtaining from abroad neutral glass plates transmitting exactly 10 per cent. of the light; but it has hitherto been a very difficult matter to get similar glass in this country.

The advance in Germany in this respect, as well as in many other special lines of optical research, can be traced to the evolution of the Jena works. In the first instance the scientific work undertaken at Jena was not directly remunerative. But the Government had the foresight to see that it had great future possibilities, and that the ability to manufacture accurate standard glass for all sorts of purposes would create a need for it. History has proved the correctness of this view. On the research work at Jena many subsidiary optical industries have been built up. Similarly, the fine glass works in Austria have been slowly developed through many years of scientific research.

Since the war broke out many manufacturers in this country have made praiseworthy efforts to fill the gap, and in many cases substantial progress has been made. Yet, taken as a whole, such efforts are apt to be unrelated and chaotic. There is a need for the co-ordination of all such individual efforts by some form of central control, and if progress is to be lasting and progressive the industry must be organised on scientific lines. Even so we cannot expect rapid progress, for time will be needed before the influence of scientific study begins to tell.

In particular it is desirable that the scientific sections of the work and the standardisation of material should be guided on some co-ordinated plan. The Institute of Chemistry of Great Britain and Ireland has already done excellent work in devising formulæ for glass required for various purposes.* It is to be hoped that for lighting purposes glassware will also be the subject of careful study. In the National Physical Laboratory we have a scientific institution which is already doing good work, and which only requires greater support to be of immense benefit to the glass industry. It has also been suggested that the scheme for a Central Institute on Applied Optics, suggested before the war, should be carried through. In such work the various scientific associations and societies throughout the country should play a part, and there are signs that the Government is willing to consider taking a more active part in fostering the industry. From personal experience I can say that the Board of Trade have already done a good deal considering their present powers. Similarly, I notice that the Board of Education has been considering the establishment of better educational facilities for instruction in glass-blowing and similar processes involved in the manufacture of scientific instruments.

In undertaking such work the authorities will have to consider both the scientific requirements of the industry and the industrial problems which I have briefly mentioned above. The problem is a difficult one but a highly scientific industry like this is well worth the effort involved as it reacts on so many other trades and professions.

In conclusion, I would like to recall for discussion several definite proposals made in the course of this address:

(1) There is a need for standardisation in respect of materials used in various kinds of glassware used in the lighting industry. It would be very desirable for a complete series of samples to be prepared, attached to each being par-

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* Particulars of some of the varieties of glass so far investigated are given in the Appendix (p. 122).

ticulars of the chemical composition, absorbing and diffusing qualities, colour, permanence and durability, and special applications.

(2) An effort should be made to standardise the dimensions of glassware used for lighting purposes, the shapes and sizes of globes and reflectors being limited to a convenient prescribed series.

(3) The conditions of testing the reflecting power and other qualities from a lighting standpoint of globes and reflectors should be more precisely formulated.

(4) An effort should be made to simplify and standardise the apparatus for testing different varieties of glass as regards colour.

(5) The Illuminating Engineering Society should co-operate with other bodies in forming a Committee to consider these problems.

APPENDIX I.

Some Notes on the Preliminary Report of the Glass Research Committee of the Institute of Chemistry of Great Britain and Ireland.

In the Preliminary Report of the Glass Research Committee it is mentioned that research has been conducted on the following glasses and formulæ specifying their compositions have been determined :—

1. and 2. Soft glasses suitable for ordinary chemical laboratory ware, which do not give up alkali readily to water, work well in the blowpipe and do not devitrify readily.

3. Resistant glass suitable for pharmaceutical purposes, ampoules, &c., intermediate in hardness between soft glass and combustion tubing, and highly resistant to chemical action.

4. and 5. Glasses for combustion tubing, closely resembling Jena combustion tubing, and having practically the same fusing point.

6. and 7. Miners' glasses, colourless and fusible and capable of withstanding rapid changes of temperature.

8. Resistance glass, almost identical in its general behaviour with Jena resistance glass.

9. An alternative glass for combustion tubing.

10. 11. and 12. Soft glasses suitable for tubing and for X-ray bulbs.

13. Glass for ordinary chemical laboratory ware, alternative to No. 1.

14. Glass for tubing, X-ray bulbs, &c., alternative to No. 10.

Since the publication of the above formulæ, some further information on Glass Research has been issued in the Proceedings of the Institute (Part I, 1916). The Glass Research Committee have lately forwarded to the Advisory Council on Scientific and Industrial Research reports on formulæ for :—

15. Blue Enamel for sealing metallic wire into glass.
16. Lead Glass suitable for electric light bulbs.
17. Lead Glass similar to above, but avoiding potassium carbonate.
18. Opal glass designed to join perfectly with glass made to the Committee's formulæ Nos. 1 and 10.
19. High temperature thermometer glass.
20. A leadless opal glass which unites with No. 19 and can be worked with it as an enamel backing for thermometers, &c.
21. Thermometer glass for ordinary temperatures.

It is added :—

"The fact that these formulæ are available has been reported to British glass makers, from whom a large number of applications have been received and are now under the consideration of the authorities."

"With regard to research on optical glass, the Advisory Council have asked that the Glass Research Committee shall keep in touch with the National Physical Laboratory, to which a grant has also been allotted. The primary object of the work of the Laboratory will be 'the study of the process and condition of melting and producing glass of good optical quality with special reference to refractories and electric furnaces methods, with a view to putting the whole process of manufacture on a practical scientific basis.'"

"The line of investigation undertaken by the Glass Research Committee of the Institute is the study of certain optical glasses urgently required for industrial purposes, with a view to their early production by manufacturers."

DISCUSSION.

The CHAIRMAN said that the subject of the paper was one of pressing interest at the present time, and called for scientific research and scientific treatment. From an industrial standpoint the problem was also a serious one, and there were conditions which stood very much in the way of the scientific and commercial development of glass manufacture in this country. It might be hoped that these difficulties, which, however, must be discussed on another platform, would be overcome in course of time.

He was glad to see that Mr. Langlands had said a good word for the Board of Trade, because it was also his experience that during the war the Board of Trade had done all that could be done to help in many ways, considering the limited means at its disposal.

Mr. BERTRAM BLOUNT, as a member of the Glass Research Committee of the Institute of Chemistry, mentioned in the paper, said he believed that Committee had done splendid work, resulting in something practical. He also supported the Author and the Chairman in recognising the extreme help which the Board of Trade had given in the matter. The main difficulties in the case of the glass industry had been Treasury difficulties, but by a plain statement and not by persuasion the Institute of Chemistry Committee had obtained the necessary monetary help which had enabled a research to be carried out for a few hundred pounds, which he believed would bring our industries into a state of great prosperity.

Mr. W. C. HANCOCK, also a member of the Glass Research Committee of the Institute of Chemistry, said that a number of glass manufacturers had actually undertaken to manufacture glass according to the formulae which had been provided. Some of them had encountered difficulties, and had asked the Committee for further help and advice which had been willingly given.

The work carried out by Prof. Jackson for this Committee at King's College had been simply tremendous, for he had not confined himself merely to the carrying out of experiments for the elucidation of the formulae, but had given most valuable help to the manufacturers. With regard to glass capable of excluding ultraviolet rays, Sir William Crookes had done a good deal of valuable work a few years ago in this connection which should be capable of useful application now. The work of the Committee of the Institute of Chemistry had resulted in several steps forward being taken, especially when the extreme shortage of glass for steel works laboratories and for miners' lamps at the beginning of the war was realised. A difficulty at first, however, was the necessity for skilled workmen, but this to a large extent had been overcome. Mr. Langland's scheme was extremely ambitious and should be undertaken thoroughly so that all interests concerned could be co-ordinated. He certainly hoped that the manufacturers would come forward and take their part in the whole scheme, because it was useless to attempt to patch up the industry in parts. There were possibilities for the glass industry in this country being made an extremely remunerative business, and the manner in which optical glass had been tackled by the Institute of Chemistry, and also by the National Physical Laboratory, showed that we had the means at our disposal for avoiding that dependence upon foreign sources which existed before the war. Such a state of things ought never to have been allowed to arise, and he hoped it would never recur.

MR. E. STROUD: The paper by Mr. Langlands, although comparatively short, opens up such a variety of questions in regard to glassware for lighting purposes, that one can only analyse and deal with a few of the chief suggestions in the time available.

The war has certainly brought home to us the extent to which we were dependent on abroad for many forms of glass, especially glass of a heat-resisting character. In my own experience, in connection with Holophane glass, these difficulties have not arisen, since glassware of this kind is manufactured in this country.

In this connection Mr. Langland's remarks are of great interest, because the utility of Holophane glassware is very greatly wrapped up with precision in manufacture and standardisation, as regards composition and form of mould. Any form of glassware which is stated to give certain illumination values with a certain type of lamp must, of course, be accurately manufactured, and the moulds used for Holophane glass have to be made with the greatest care: in the larger sizes the number of calculated faces may amount to many hundreds, and the correct reflection of the rays depends on the angle of the prisms being exact and the surface of the glass highly finished.

Seeing that we deal with transparent glass we have the advantage of extremely low absorption values.

The variation in distribution is achieved by shaping the prisms, and we have only to produce consistently glass of uniform colourless transparent quality. It is of course vital that any tendency to yellow colouration should be avoided, and we find that with our reflectors the colour of the light from any form of lamp is not affected, as it might be by cloudy media.

As regards the question of heat resisting power, we have adapted Holophane reflectors very widely for gas, and find no difficulty in obtaining units which do not crack or discolour with the heat; I should like to point out that in our experience success in this respect is often as much a matter of correct design of unit, provision for ventilation, and expansion of glass and gallery as quality of glass.

The question of standardisation, as suggested by Mr. Langlands, is a very important one. If by "standardisation" he means exact reproduceability in the quality and dimensions of units, we can claim to have done pioneering work in this direction. If, however, it is implied that the units supplied by different manufacturers are to conform to a given range of dimensions, this is a much larger proposition. The first step in this direction should clearly be taken by the makers of lamps and burners, to whose requirements manufacturers of reflectors must, to a great extent, conform. As was suggested at a recent meeting of this Society, a more complete understanding as to standard sizes of bulbs and positions of filaments therein would be a great advantage, as the results obtained from any reflector are naturally dependent on these factors; however accurate we may be in standardising the reflector, the illumination obtained will vary if the position of the filament within it alters greatly according to the type of lamp used.

I fully agree with the remarks of the author regarding the need for greater precision on defining the "reflecting power" of various units, and the amount of light absorbed. There is a great deal of misapprehension on this point, and the question should always be considered in conjunction with the general qualities of the unit. Some units have a low absorption value, merely because they do very little reflecting, and there ought to be a standard practice in testing the absorption and other properties of glasses.

The question of selecting certain sizes of units to fall within a predetermined intrinsic brilliancy is also a somewhat difficult one; naturally in designing Holophane units we have kept this matter in mind, but it is obvious that much depends on the position occupied by the lighting unit. In other words, the supply of the lighting unit must go hand in hand with a knowledge of how it should be applied in practice. This has always been our practice, and we fully recognise the need for precision in manufacture in order that predeterminations of illumination may be carried out in the actual installation.

Mr. A. P. TROTTER said the question of glass was a very wide one and was divided into various branches, which had very little to do with each other. There was the question of optical glass, chemical glass, and glass for lighting purposes. This latter included shades, globes, chimneys and so forth, and in the case of gas shades, heat difficulties were encountered. Then there was another important section, the so-called opal glass which he regarded as a convenient term covering a large number of different kinds of diffusing glass. It was very desirable that the buyer of glass or of glassware should know definitely what he wanted, that he should be able to describe it in accurate terms, and that the dealer or manufacturer should be able to understand the description and to know whether he was able to supply the goods. In 1882, when he brought out his dioptric shades, which were the forerunner of the Holophane system, he had great difficulty in finding any manufacturer who could undertake to make them. In discussing the matter with a well-known firm he asked the manager, " What is the refractive index of your flint glass ? " " What index ? " " Refractive index." " Oh, we have nothing of the kind ! " The Americans were far ahead of us in this matter of opal glass or milk glass as it is sometimes called, and had magnificent laboratories in which researches were carried out by men who gave their whole attention to the technology of the subject of glassware. The subject was encumbered at present with a number of trade names ; some of these referred to combinations of opal and ground glass. Flashed opal consisted of a thin layer of densely turbid glass spread over a sheet of transparent glass. Some kinds of opal glass had very poor mechanical qualities, and the clear glass acted as a support. Most glasses of this kind showed the lamp behind of reddish colour (and which could easily be explained optically) and that was surrounded by a diffused light. This differed from ground glass, where one saw a large patch of light surrounded by a dimmer patch, which could also be explained optically. The Americans had succeeded in producing a dilute mixture of the diffusing material with clear glass, and had produced rather clumsy shades, very thick and heavy, but with peculiar scattering characteristics. Volume 10 (p. 353, *et seq.*) of the Proceedings of the American Illuminating Engineering Society contained a good deal about diffusive reflection and transmission, but the theoretical part was too mathematical and theoretical and the experimental results were of little or no practical use to manufacturers.

He himself began some years ago an investigation of the scientific aspect of the scattering of opalescent or general translucent substances, and of the analogous subject of the scattering of a white reflector, but it required a great deal of experiment, and he could only do this in his spare time, and at present he saw no chance of going on with it. The behaviour of translucent substances differed a good deal, as everyone knew from the grease spot on the Bunsen disc, where a change in the direction of view showed that the law of scattering of the paper was not the same as the law of scattering of the wax.

There was some difficulty in dealing with the author's conclusions. In the first, dealing with standardisation of materials, he asked for samples. While it would be a good thing to have samples so that one would be reasonably sure of getting something near what was ordered, he did not see how manufacturers could be asked for the chemical composition of their glass. As to standardising dimensions of glassware, that in itself was good, but the author suggested it should be limited to a convenient prescribed series. Personally, he thought there had been too much standardisation, in certain branches of electrical and other engineering, and he would hesitate about adopting restrictions which would limit choice of sizes. As to the third conclusion, that was a highly scientific matter and had already received a large amount of attention from the Society. It would be rather difficult to standardise, although it would be well to know that a reflector, for which certain powers were claimed, had been intelligently tested. As to standardising a testing apparatus for glass as regards colour, that had been very largely done scientifically and by the spectro-photometer, as well as by other methods which were practically effective up to a certain point, but entirely unscientific, such as that adopted by Mr. Lovibond. The question of artificial daylight had been gone into some time ago by the Society, and he had shown an instrument for testing lamps of that kind. Daylight lamps at that time were very poor, but the Americans had since gone ahead very rapidly. His own apparatus was now in the hands of a manufacturer, who, however, found it perfectly impossible to touch it on account of the war.

Dr. M. W. **Travers** said that Jena resistance glass, and the glass from which

Duroglass, Ltd., manufactured chemical glassware and gas globes, were practically the same thing. The selection of a glass for these purposes was always a matter of compromise, for while one kind of glass was very highly "heat resisting," another kind was more inactive towards chemical reagents, and did not "fog" when exposed to combustion products of gas. While, for instance, "Monopel" glass was more highly heat-resisting than Jena glass, it fogged more readily. This appeared to be due to the presence of lead and antimony in the former. His firm preferred to manufacture a glass free from these heavy metals, which they entirely excluded from their works, as they were objectionable as impurities in chemical glass. If they were to undertake the manufacture of gas globes on a larger scale it would be necessary to consider the matter further, and to work out a glass most suitable for this particular purpose. With regard to standardisation, he had to point out that we had not really advanced very far in our knowledge of glass, and its manufacture, in this country, and that standardisation, might mean sterilisation. This applied even more to methods of manufacture than to varieties of glass, for given any one kind of glass there would probably be at least "nine and fifty ways" of producing it, and both formalæ and works practice could be varied considerably. The manufacturer would, however, like to see an attempt at standardising patterns and sizes, the variety of which appeared to be unlimited.

Mr. J. S. Dow said that since the war began a number of glass makers had been making independent efforts to produce the so-called "heat-resisting glass" for use with high pressure gas lamps, &c., and no doubt some measure of success had been already obtained. But from what he had heard it appeared that there were considerable variations in the quality of glass sold under this title; in some cases the glass was quite good, in others very far from justifying comparison with Jena glass. He had had an opportunity of seeing at the Institute of Chemistry some of the samples of laboratory glass of various kinds, on which the Research Committee of the Institute had already done such good work, and had been particularly interested in the specimens of combustion tubing. The formula for this glass was known, and it seemed possible that, with a little modification, this work would also have an application to heat resisting glass required for use in the lighting industry.

Mr. Langlands and Mr. Trotter had both referred to the need for standardising the qualities of opal glasses. There is little doubt that the globes and reflectors of this type in use at the present moment are very unequal, some being satisfactory but others unsatisfactory in colour, uniformity and diffusing effect.

Similarly the question of preparing coloured glass screens for the production of "artificial daylight" needs attention. Screens of this kind have been described at several meetings of this Society. They have been prepared for use with incandescent electric lamps (of which bulbs of special daylight glass have also been blown), for incandescent mantles and for arc lamps. No doubt they would also be very readily applicable to the half-watt lamps. This question of producing convenient small artificial daylight units is of considerable proportion importance in the dyeing and textile industries and in other work where accurate colour matching is involved. In this case scientific precision and accurate reproduction of glass is essential. It is not desirable that there should be a great variety of glasses all claiming to give artificial daylight with a particular illuminant, but all departing from it to a greater or less extent. It should be possible to ascertain scientifically with the spectro-photometer how near to average daylight we can get with different illuminants, and the glass required in each case should be accurately specified so that it can be reproduced by any glass manufacturer. The solution of this problem demands the combined work of the photometric expert, the chemist and the glass manufacturer. The Illuminating Engineering Society might with advantage approach the Institute of Chemistry and the National Physical Laboratory on this matter.

Another problem of importance not only to photometric workers, but to all who have to do with optical instruments, is the production of standard neutral-tinted glass. Such glass is an essential product in many scientific experiments in optics; yet, before the war, it was impossible to purchase in this country plates of neutral glass guaranteed to absorb a certain percentage of light—although a series of such glass has been produced at Jena and has long been listed by glass makers and scientific instrument manufacturers in Germany

Mr. Dow added that he had had personal experience on this matter when endeavouring to get dark glasses respectively transmitting 10 and 1 per cent. of the light for the Lumeter photometer. Such glasses are essential in order to get a really wide range, for example to measure up to 1000 ft.-candles or more. Although he had the advantage of the advice of Mr. Conrad Beck, they were unable to get any standard neutral glass in this country and eventually they had to pick out some sheets by inspection, and afterwards cut them down and find out by trial and error the required thickness. Even then the glass was not strictly neutral and it was found necessary to combine two samples (one too red and one too green) in the form of a wedge in order to make a suitable screen.

These instances, Mr. Dow concluded, showed the need for standardisation. Naturally glass makers would always have their individual preferences and differences in method. But it seemed highly desirable that there should be some central source from which definite information on standard glasses of the kind indicated above could be obtained, so that our knowledge on such matters could be permanently placed on record. In this way people would know that there was in existence at least one complete series of formulae for glass of every description, to which recourse could be had in any difficulty. The Institute of Chemistry appeared to have already made an excellent beginning in this respect.

Mr. O. P. MACFARLANE spoke on the question of glass required to withstand the intense heat produced by incandescent oil lamps. In this connection "Monopel" was certainly a very fine glass, but was exceeded in its heat-resisting power by another glass coming from Prussia known as "Resisto." Jena glass was not of first-rate quality as regards heat resistance, but was very good with regard to absence of fogging.

He would like to encourage glass-makers in this country in the production of heat-resisting glass because it should be a very lucrative business. It would require very careful manipulation, because the quality and the uniform thickness was all-important. Samples of British-made globes which recently came into his hands were as irregular as the waves of the sea, and their production was remarkable. Inequalities in thickness were almost fatal to a glass required for heat resisting purposes. He thought that one of the greatest weaknesses at present was the lack of skilled workmen. It was perfectly wonderful to see the regularity and precision with which glass was produced on the Continent. Americans had endeavoured to supply this country with this glass, but the results had been very disappointing. In appearance the American glass approached very closely to the German, but it had not got the same heat-resisting quality, notwithstanding that German workmen had been taken into American factories. Apparently they had not obtained the cream of the workmen.

MR. L. GASTER said he quite concurred in the view that it is not necessary to have so many different globes, bulbs, and chimneys, differing not only in the nature of the glass but the dimensions as well. Naturally globes and shades would have to be of different qualities according to the purpose for which they were intended, and a fair amount of latitude must be allowed for individual taste. But one could not but feel that in many cases, particularly as regards the cheaper types of glassware, these variations were not the result of deliberate attempts to meet certain problems, but arose through the haphazard way in which individual people decided on their own requirements, without any attempt to co-operate with others in fixing a common size or quality equally convenient to all of them.

It was advisable for the glass manufacturers to combine on this matter, but responsibility also rested with the makers of lamps and burners, on which the sizes of glassware largely depended. As an instance of extreme needless variations, he might mention the differences in the sizes of burners for oil lamps or for petrol air gas-machines; small deviations were common, which could surely have no necessity as far as results were concerned, and the same held good to a greater or less extent in the gas and electrical industries.

In the case of oil lamps it is of course well known that the design of the lamp is necessarily affected by the kind of petroleum for which it is intended, and this may entail a difference in the dimensions of the chimneys. It should, however, be feasible to ensure that for lamps using the same kind of oil the sizes of chimneys are limited to standard sizes, which are found to give the best results. In this way greater uniformity as regards performance might be secured, besides materially diminishing the cost of manufacture.

In the United States co-operation between the makers of lamps and shades was more usual. The lighting unit, comprising both lamp and shade, was considered as a whole, the result being the standardisation of the conditions producing the best lighting effect, as well as enabling the unit to be most cheaply and expeditiously put together. Naturally time would be required in this country to bring the different makers into line. But it would be at least a great step forward if a series of standard sizes, considered the most satisfactory from a practical standpoint, could be determined upon and exhibited as those accepted by the lighting industry in principle. This would at once have the effect of bringing a number of makers into agreement, and others would follow.

This question of standardisation is of vital importance to the manufacturers of glassware in this country. So long as dealers were content to rely on imported glass divergencies in size were less important. But if glass manufacture is to be undertaken as a national industry on a large scale it is essential to limit as far as possible the present multiplicity of dimensions, as it is only by concentrating on standard forms that a substantial diminution of the cost of manufacture can be expected. Naturally, in regard to glass of a "luxury" type, where individual preferences play an important rôle, standardisation need not be carried far. But in regard to everyday articles which have to be produced in large quantities it should lead to most useful results.

Mr. Gaster also wished to associate himself with the remarks of Mr. Langlands on the testing of globes and reflectors. At present one could buy electric incandescent lamps by specification, and it seemed to him that ultimately one ought to be able to purchase globes and reflectors and shades for use with them under equally definite conditions. It was surely an anomaly to pay great attention to the illuminating power of the lamps, and then to abstain from stating precisely the qualities desired in the globe shade or reflector by which the rays of light were distributed. Mr. Stroud had referred to the pioneering work carried out by the Holophane Company in this respect, and during the last few years a great advance in this respect had been made by the various manufacturers of lighting appliances, who were now supplying polar curves with their lighting units. The time seemed ripe for adopting a standard method of procedure in testing and specifying such units, and he agreed that it would be a great advantage if the articles supplied by different companies could all be tested under similar conditions at a central laboratory. Here, again, he had in mind globes and reflectors employed for ordinary practical lighting problems. Fancy glassware of an ornamental kind would naturally fall into a different category, as definite predictions of the illumination provided were not so important in this case. But in commercial lighting the tendency was to standardise lighting units so that the illumination required could be specified beforehand and provided subsequently, and in order that this should be done successfully specification of both lamps and reflectors was needed.

As regards the qualities of glass required in the lighting industry, one of the most urgent problems was undoubtedly the production of suitable "heat-resisting" globes. The extremely valuable work done by the Glass Research Committee of the Institute of Chemistry had shown what could be done in connection with laboratory glassware, and he thought that the extension of their researches, so as to include glassware required in the lighting industry, might lead to most useful results. The whole question was one for co-operation between the various parties concerned, and he welcomed the suggestion that the Illuminating Engineering Society should appoint a Committee to deal with the matter, and to promote the necessary co-operation with other institutions concerned.

Mr. W. M. MASON, speaking on the practical side from the gas point of view, said that five or six of the largest municipalities or companies in the United Kingdom had an annual turn-over amounting to no less than three million different items of glassware, of a value of at least £50,000. Perhaps this would be of some interest to glass manufacturers in encouraging them to cater for this trade. At the recent British Industries Fair he failed to find that any glass manufacturer was prepared to do anything on a really substantial scale, and it was put to him quite plainly that the position was that glass manufacturers would not put down £10,000 or £20,000 worth of new plant for the gas industry with the prospect that immediately the war was over orders would again be given to Austria and Germany.

In these circumstances, the formation of a Committee, which might make some working arrangement with the gas companies and municipalities to support those people who were prepared to invest money in the glass business, would be a useful step. He was delighted to find only yesterday that a Glasgow firm had come to the rescue and were actually making glass to replace Austrian glass, and were prepared to still further extend their activities in this line. He thought that the Society might suggest some means by which English, Scotch, and Irish gas undertakings would take a certain amount of their glassware from firms who were willing to go into the business; if this were done then he matter was solved.

Mr. R. W. HOOD (Edison and Swan United Electric Light Co., Ltd.), said that some degree of standardisation would undoubtedly be very helpful to glass manufacturers. In the electrical trade alone there were no less than 200 different types of bulbs, and he could not think that so many varieties were necessary.

He quite agreed that the scientific study of the composition of glass for various purposes was very necessary. At the same time he thought that those interested in the preparation of formulæ should recognise the practical difficulties in making glass to schedule. For example, there were some materials which could not be obtained in a state of perfect purity, and a minute percentage of certain impurities would at once exercise an effect on the colour or opacity of the glass. Such impurities might occur in the materials supplied for mixing, but might also even enter into the mixture by being absorbed from the material of which the pot was made.

Another important point was the temperature attainable. It was well known that the majority of the furnaces used in this country employed solid fuel, and in this case one could not conveniently attain the temperature reached in the gas-heated furnaces largely employed abroad. The furnaces answered perfectly for the kind of glass we in this country were accustomed to make, but could not at once be applied to making those glasses, hitherto mainly imported, which could only be made at a very high temperature. He hoped, however, that this country would shortly be in a better position in this respect.

The point deserved consideration, because it was quite possible to work out a formula which could be used for producing heat-resisting glassware on a small scale, but might be restricted in practical application, because few manufacturers had the facilities for applying it.

Further, the same mixture at different furnace temperatures may give entirely different results.

Mr. GUY CAMPBELL thought that it would be some years before English glass manufacturers would be able to provide the capacity to meet all the requirements of the lighting trade.

It might interest Mr. Langlands to know that with regard to the white pressed glass variety of lines, although there have been attempts to produce this excellent quality of diffusing glassware in Europe, they did not meet with success. Its production is mainly a matter of formula.

With regard to artificial colour-matching, it is most satisfactory that with the improvement of illuminants the difficulty of colour-matching artificially grows less. Many years ago someone was responsible for the use of coloured glass in connection with the arc lamp to obtain a colour-matching unit. This was placed on the market in connection with "Jandus" arc lamp, but little is heard of it to-day. The glass plate with two films shown by Dr. Kenneth Mees before this Society, and which gives approximate daylight results with the tungsten lamp, has not been widely used, neither have the electric lamps mentioned by Mr. Langlands. It seems we must wait for the new unit which will give without assistance of any kind direct results before consumers will take kindly to artificial colour-matching units.

As to standardisation of quality, this was really a question of price. The higher the price the better the quality, and whilst there were two or three classes of customers a cheap market like India and an expensive market like this country, two qualities must be produced.

A standardisation of materials to be used in the manufacture of glassware is not likely to be appreciated by the manufacturers, who generally have their own views on the mixture they consider likely to produce the most satisfactory results; it would, therefore, be a difficult matter to procure, while possible improvements might be neglected.

The standardisation of designs, shapes, dimensions, etc., is a splendid idea from a glass manufacturing point of view, but any committee formed to deal with it would be up against a very big problem, because it would mean that all manufacturers of gas burners and lanterns, electric incandescent and arc lamps, would have to strictly follow the said lines, and therefore the existing tools, equipment, and in some cases patents of such manufacturers would be worthless. There was the aesthetic side to consider, because we did not always want to see the same size and shape everywhere; further, also, the human element came in here, because manufacturers invariably when they brought out something new wanted it to be different from any other product, apart from the logical fact that all improvements in lighting do generally and very considerably differ from its predecessor. Take the fish-tail burner and the modern high-pressure inverted incandescent gas burner; the first Edison carbon lamp and the latest gas-filled lines, all of which are in use, needing an entirely different glass accessory or ornament, while decoration is a fashion.

The suggestion that there should be an independent testing laboratory for all illuminating engineers was a good one and it might be arranged, for no doubt financial help would be forthcoming from the large gas and electrical undertakings.

Mr. EDWARD C. BARTON, referring to Mr. Trotter's remarks on glass for transmitting light of various colours, absorbing or transmitting ultra violet light, &c., mentioned a very useful paper by Professor P. Mercanton, published recently I believe—in 1910 or 1911—in the Proceedings of the Société Vaudoise of Lausanne. This contained a very complete summary of the qualities of special varieties of coloured glass, the results of photometric and spectroscopic analyses being given.

Mr. GEORGE HERBERT exhibited three very unsatisfactory screwed well glasses of English manufacture; all were selected from the same consignment and all supposed to be of the same dimensions, quality, &c.

He explained that whereas one was very light and brittle, another was too small for the screw it was intended to fit, whilst the third was too large.

The object of showing these glasses was to impress upon the manufacturers of this country the necessity of making a standard article which would be acceptable for use in explosive factories (as it is usually stipulated that these glasses must not exceed certain dimensions), and on account of the English manufacturers not meeting these requirements, orders have passed them and been placed with firms abroad.

Mr. Ed. Dobbins (*communicated*): Your invitation to participate in the Discussion at the last meeting of the Illuminating Engineering Society on some aspects of the design and use of window glass for Natural Illumination was much appreciated, and I am sorry that I found it impossible to attend. I have, however, much pleasure in sending a short written contribution on the subject.

The design of such glass forms quite an important section of glassware used for lighting purposes, not only in connection with admission of light through windows in the case of buildings overshadowed by neighbouring obstructions, but also as regards pavement lights, &c., for basements and underground passages.

During the last few years I have visited a very large number of factories in this country, and have been struck by the care some proprietors bestow on the frequent cleaning of window glass and the preservation of a light tint for ceilings and walls, by which alone a very great improvement in the amount and distribution of light has often been obtained. Seeing how great a proportion of the work of a factory is carried on by daylight, the proper utilisation of daylight is surely of commercial importance, both in its relation to the amount of work done and its influence on the ease with which operations can be carried out, and in view of the hygienic value to the workers of good natural illumination. In the case of buildings of a somewhat antiquated type, with small windows, or buildings where the loss of daylight through the obstruction of trees or surrounding buildings is considerable, the use of accessories to increase the amount of light entering the rooms is particularly important. For this purpose light refracting glass panes which serve to divert into the room a considerable amount of downward light, which otherwise would not be utilised, is frequently of considerable service ; if, by such means, the duration of time during which the room can be lighted by natural means without it being necessary to employ artificial light can be even slightly increased, the resultant saving may more than compensate for the cost of installing the special glass. Another point to be noted is that in many cases it is essential that a form of glass should be used which obstructs the vision from within or without ; therefore it is worth while to select a glass which, besides having the necessary obscuring effect, increases the percentage of daylight available. I understand that the Society has devoted attention to the question of specifying for buildings a minimum percentage of the total unrestricted daylight illumination which should find access to a soom Properly designed window glass would often be useful in bringing this figure up to the proposed value.

As regards the nature of this special prismatic window glass, the correct shaping of the prisms so as to diffuse the light longitudinally and horizontally, so that inconvenient shadows are eliminated and the light is directed into the room at the requisite angle, requires some care. The design of the surfaces is also affected by practical conditions. For example, some forms of glass have too many lines on their surface, making them very difficult to clean, and causing an obstruction of 20—30 per cent. of the light. It must also be borne in mind that the allocation of window space in a room is usually a compromise between lighting and heating conditions. As ordinarily used the glass should redirect the light in such a way as to increase substantially the illumination at points in the room most distant from the window, this securing additional light without structural alterations. In very hot and sunny districts, however, this may occasion an undesirable rise in temperature. In such cases we have sometimes installed the glass in the reverse position so as to direct the light upwards on to the ceiling. This method of working on the "indirect lighting" principle with daylight gives excellent diffusion.

Naturally the degree to which the rays of light are diverted depends on the quality of the glass, and for our purpose glass having a comparatively high index of refraction is essential. The glass should also be colourless and transparent. We have no difficulty in getting the desired kind of glass manufactured in this country.

Mr. H. Hugh Walford [Messrs. Chance Bros. & Co.] (*communicated*) :—I regret that pressure of work does not permit my being present to hear and discuss the many interesting points so ably introduced by Mr. Langlands. I should have been glad of the opportunity of drawing attention to the many difficulties with which one is surrounded at the present time in endeavouring to meet the urgent and sudden demand brought about by the war for heat resisting glass.

Members present will fully appreciate that skilled glass workers are not only extremely scarce, but are in exceptional demand for the manufacture of other kinds of glass vitally important to the nation at this juncture. Moreover the manufacture of heat resisting glass of Jena quality is entirely new to us, and there are many special features in connection with it which are full of difficulties at the present time.

I mention these points in order to solicit the patience and consideration of lamp makers and others. We have succeeded in making heat resisting glass similar to the Jena glass, and we are to-day sending out globes which we are given to understand are in every respect equal to or better than the German product. Our output is of necessity limited by the exigencies of present conditions, but we hope that with the co-operation of buyers we may before long be able to meet the demand.

There is practically only one direction in which this co-operation can materially assist this result, and that is the standardisation of sizes, to which Mr. Langlands has referred. There are scores of varieties of globes almost identical in shape and weight, but differing by millimetres in rim diameter or in other dimensions which are in no way essential to the purpose for which the globe is used. This sort of thing makes it utterly impossible for a manufacturer to keep a stock, and also adds materially to the cost of the individual globes. It might not be so serious if labour and other things such as materials and fuel were plentiful and the demand normal, but in the present circumstances, it is simply checking and hampering the progress of the manufacturer, and giving rise to considerable hesitation as to the advisability, or even possibility, of seriously going into the trade on permanent commercial lines.

I do press most earnestly the point of standardisation of sizes and shapes, without which it is hardly too much to say that the future of the manufacture of heat resisting glass in this country can scarcely hope to be established.

Messrs. STEVENS AND WILLIAMS LTD., Stourbridge, write as follows:—"We have given a good deal of attention to lighting glass but mostly for artistic lighting in private houses. We are in accord with the expressions in the address as to the need of standardising various kinds of glass and the dimensions of the glassware used in the lighting industry, but it seems to be a problem of considerable difficulty. Owing to the scientific knowledge of glass gained by the Germans through the establishment of the Jena laboratories, they were able to capture the bulk of the lighting industry, and we feel confident that if efforts were made in the direction of scientific investigation in this country, backed by the Government, England would be in a far better position than formerly to compete in the markets of the world."

Mr. W. C. CLINTON (*communicated*): I have read the copy of the paper which you kindly forwarded to me and consider it highly suggestive, although one cannot quite agree with all the proposals made by the author.

It is doubtful whether we have attained that pitch of perfection in the manufacture and design of glassware that would make standardising desirable as suggested in proposals (1), (2) and (4), but (3) and (5) are deserving of serious attention.

Behind all this, though, lies the question of the Governmental attitude to specialised industries in general.

Alderman R. BURTLES [Messrs. Burtles Tate and Co.], Member of the Lighting and Gas Committees of the Manchester Corporation (*communicated*):—I have read with considerable interest the paper by Mr. Langlands, a proof of which you kindly sent me, and much regret being unable to be present at the discussion.

Since the war our firm, along with other firms, has gone in for glassware for lighting purposes and I can fully endorse the importance—the very great importance—of standardisation not only of the materials used in the various kinds of glassware used in the lighting industry but also in the sizes of the glassware required. At the present time every lamp maker seems to go in for a special size of his own, causing, as Mr. Langlands states, much inconvenience besides making it necessary to carry so much extra stores. Even railway companies are the same in this respect, almost every company having its own sizes of glass bowls for lighting the carriages.

With regard to heat-resisting properties of British-made glass globes there is a great deal to be said in regard to the regular distribution of the glass throughout the globe and the reason these globes are now so much improved since the British manufacturers commenced making them is that the operative glass maker, being continuously making various sizes of globes has, by practice, become more efficient in this respect, blowing the globes out more regular in thickness. It must follow that irregular distribution of glass, leading to variation in thickness of the globe, makes it more difficult for them to withstand the varying temperatures to which they are subjected. Hence it is questionable whether *all* the blame attributed to the composition of the glass is due to that cause alone; and as it is expected that this trade will remain in the country after the war there is no doubt that British manufacturers will be able to work up to the necessary efficiency.

In my opinion the addition of a certain amount of lead oxide (red lead) to the composition of the mixing tends to mellow the glass, enabling it to be worked more uniformly, and would also tend to assist the contraction and expansion caused by the varying degrees of heat inherent to their use.

Mr. DUNCAN WEBB (Messrs. Molineaux, Webb and Co., Ltd.): The decline of the glass industry in this country is mainly due to costs of manufacture. The German and Austrian glasses are very inexpensive, and the readiness with which they break is accountable for the enormous trade. Good quality is never attained at a low cost.

I think comparative tests of glasses of different chemical composition and physical properties, construction, &c., would result in the production of a better article than the imported varieties. Such tests should be on a practical scale, not merely laboratory research, and the cost should be defrayed by the Government. Unless, however, the manufacture can be carried on in this country with profit, this will not revive the industry.

As regards the technical question, I would remark that lead does not cause "fog," as I understand the term, and I have made thousands of tons of lead glass. The cause is well known, and the fault occurs in any glass of unstable composition.

Mr. F. W. THORPE, Verity's, Ltd. (*communicated*):—We are still dependent upon foreign suppliers for glassware principally for the reason that an English maker will not, or cannot, blow or press other than prismatic glass into a mould; therefore one dreads to adapt English white glassware for semi-indirect lighting for the trouble that ensues. Further, we are unable to develop lighting fixtures to our own ideas through failure in finding a glassmaker to carry them out, and, consequently, being forced to employ pressed glassware from America, which, in many instances, is first imported from the Continent.

Occasionally one finds a bowl or shade well thought out in design and which it is possible to use on a good lighting fixture, but what gain or advantage is there in using the productions of other countries, being always compelled by lack of local supply to follow, instead of to lead, others in ideas concerning illumination? We could produce designs more suitable to our own requirements if a source of manufacture could be found.

Much could be done by co-operation between the glassmakers and the Illuminating Engineering Society as suggested by Mr. Langlands, especially with a view to standardising bowls and reflectors required for commercial and general lighting, which would undoubtedly assist in the establishment of a sound British glass industry. The serious shortage of good glassware, and the necessity for avoiding large size bowls, is leading to the evolution of a new type of fixture in the form of a series of three, five or more small English bowls supported by metal, or other material, designed to support the glass without in any way causing inconvenient shadows. This system is very convenient for it avoids the use of single high units which are very expensive and which, for reasons of economy, are being substituted by a series of smaller half-watt lamps. This system obviates the use of imported glassware and architects have been quick to realise—judging from recent domestic and public installations—that this method of lighting lends itself so much more to variety of decorative treatment than the bowl type of fixture one sees in every shop, invariably of the same outline, and nearly always the same in illuminating effect. One welcomes a design away from their monotony. The present glass difficulty is rapidly leading to the development of a new type of scientific lighting fixture.

Mr. S. B. LANGLANDS, in reply, expressed his thanks to the meeting for the very interesting discussion which had taken place upon his paper. He was glad to be confirmed in his view as to the manner in which the Board of Trade had helped in many matters since the war. His experience was that the Board was always ready to step forward and try to assist, and in his opinion the Board had risen to the occasion as far as their limited opportunities had allowed.

As to standardisation, he appreciated the need for avoiding hardship or limiting progress, but he thought at present there were needless variations. The matter had been brought to his notice by the electrical engineer in one of the boroughs in connection with the question of arc lamp globes. He (Mr. Langlands) was at the time using one type of globe with two or three types of lamps, his department adapting the globes in order to obtain satisfactory distribution of light in each case. It would seem that these differences were multiplied more from human caprice than any real necessity. He was glad to have Mr. Stroud's remarks on standardisation and he still held that there could be a very large amount of standardisation without interfering with development and ingenuity. Rational standardisation was required.

He hoped that the Institute of Chemistry would extend their good work to lighting glassware. He could quite understand that glass makers might experience difficulties applying some formulae, but these workshop difficulties were eventually overcome. The glazing of workshops had been mentioned in one of the letters read by Mr. Dow, and in this connection it might be interesting to say that one of the big munitions factories in Glasgow had been constructed from glass from top to bottom, and from the daylight lighting point of view was one of the most ideal workshops in the city. Moreover when working at night with artificial light the glass contributed a considerable amount of reflected light.

Mr. Trotter had referred to opal glass, and America had undoubtedly made great developments in this branch. In this connection he would like to draw attention to a paper published in America called the "American Glass Budget." In the last issue of this, a lot of good information was published. The Americans were bringing in machinery for doing by centrifugal forces what had hitherto been done by the blowpipe.

A hearty vote of thanks was accorded to Mr. Langlands at the conclusion of the discussion.

PERSONAL.

AN agreement has been concluded with Mr. Clifford C. Paterson, M.I.E.E., A.M.I.C.E., principal Assistant in charge of Electro-technical and Photometric Buildings at the National Physical Laboratory, to join the Osram-Robertson Lamp Works Ltd. as Director of Laboratories for Research and Technical Manufacturing purposes. The arrangement will commence at the conclusion of the war or before that date, if possible.

THE CANDLEPOWER OF SERIES GAS-FILLED LAMPS.

It is well known that the distribution of light from half-watt lamps varies considerably and that the ordinary method of rating such lamps in terms of the horizontal candlepower is unsatisfactory.

Some useful evidence on this point is contained in some experiments by R. C. Robinson, carried out in the United States* on four types of series gas-filled lamps having filaments respectively vertical, horizontal, diagonal and V-shaped. For these four lamps the following data were obtained :—

Filament mounting.	Volts.	Amp.	Watts.	Mean Horizontal.		Mean Spherical.		Reduction factor.
				Candle power.	Watts per candle.	Candle power.	Watts per Candle.	
V shaped	9·5	6·97	66·2	100·7	0·66	82·5	0·805	0·82
Vertical	10·76	7·02	75·5	126·8	0·595	93·7	0·805	0·74
Horizontal	10·73	7·07	75·9	93·5	0·82	95·2	0·800	1·01
Diagonal	11·2	6·93	77·5	122·0	0·635	97·2	0·815	0·78

In view of the varying character of the reduction factor it would seem that such lamps are best specified in terms of their mean spherical and not their mean horizontal candlepower.

LIGHTING A SMALL ART GALLERY WITH GAS-FILLED LAMPS.

In a recent number of the *Electrical World* the lighting of J. J. Hill's private gallery at St. Paul, Minn., U.S.A., is described by A. L. Abbott.

The gallery is equipped with a skylight and the artificial illumination was provided by installing above the glass a series of gas-filled lamps with concentrating reflectors. The lamps were inclined so as to direct the light diagonally on to the walls of the room and in this way an illumination of about 6½ foot-candles was evenly distributed over the wall-area. It is pointed out that this method is much more convenient than the production of uniform illumination by means of a diffusing glass ceiling and the difficult problem of securing even illumination over the expanse of wall is quite economically and satisfactorily solved.

The light enters the room in a similar manner to daylight and the lamps being quite out of the range of view from the floor there is no risk of glare. In this room there are forty-four 100-watt gas-filled tungsten lamps installed. The expenditure of energy works out to 42 watts per linear foot of wall.

HEADLIGHTS FOR RAILWAY-TRACK LAYING.

A recent article in *Popular Mechanics* describes the construction by night of a strategic railway in South Africa. As the railway was being built the foremost truck carried a 50 ft. boom projecting in front of it and bearing a series of 100 cp. electric lamps mounted in reflectors and throwing the light downwards on the section of track being prepared. The truck also carried a pair of projectors for casting a horizontal beam on the more distant parts of the track, illuminating it for a distance of 120 feet. A strong downward illumination was thus continuously directed on the portions of the track under construction, and as the train moved forward on the newly laid rails a new section would be continually lighted up ready for work. The electricity for the lamps was derived from a dynamo driven from a 5 h.p. oil engine mounted on the truck.

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* *Lighting Journal*, March 1916.

A SUGGESTED CODE OF LIGHTING FOR FACTORIES, MILLS AND OTHER WORK PLACES IN THE UNITED STATES.

Presented at the Ninth Annual Convention of the Illuminating Engineering Society, U.S.A., held in Washington, September 20th to 24th, 1915 ; abbreviated.)

(*Concluded from Vol. VIII., page* 455.)

Section X. Systematic procedure should be followed in changing a Poor Lighting System over to an improved arrangement.

Using the Shop Force.—In large factories or mills, a wiring or gas fitting force is sometimes a part of the maintenance division. The work of the wiremen or fitters is likely to be heaviest in the winter due to the dark days. Where this condition exists, there is all the more reason to apportion out new work so as to accomplish it during the months of least wiring and piping repair activity, and further, at that time of the year when employees will be comparatively unaffected by the disturbances usually associated with a change from an old to a new lighting system through possible irregularities in the illumination service while the wiremen or fitters are at work.

Distribution of Expense.—Another feature different from the foregoing viewpoint, is in the distribution of the installation cost over a relatively long interval. If, for example, the system is desired for the approaching winter, the complete wiring or piping plans may be drawn up and blocked out into three, four or even more sections, thus spreading the expense over as many months.

Yearly Appropriation.—In some shops a given appropriation may be allotted each year for building equipment. From the standpoint of finance plans, it may thus be desirable to distribute outlays of this nature over the year, rather than to concentrate them at any one time. *An important consideration in this method of installing lamps, however, is to prepare in as far as possible the complete plans in advance, at least as regards given factory or mill sections, so as to insure a uniform and symmetrical installation as a whole when the component parts are finished.*

Section XI. Reflectors and Their Effect on Efficiency.—A reflector or shade is used in conjunction with a lamp for the purpose of reducing the glare otherwise caused by looking directly into the bare lamp, as well as for the purpose of redirecting the light most effectively to the work.

Reflectors and shades are now obtainable so designed as to be specially adapted to give sizes and types of the smaller and medium sized line of lamps, and hence care should be used to be sure that both reflectors and lamps are of the correct size in their relation to each other. This is of the utmost importance in securing uniform illumination for a given spacing distance and mounting height of the lamps. For a certain ratio between the spacing and the height of the lamps, a reflector can nearly always be selected which will furnish uniform illumination over the working surface. (These remarks concerning reflectors apply particularly to lamps of the tungsten type and to small gas units.)

Function of Reflector.—Owing to the direction of the light from the lamp, nearly all types of lamps, in addition to the downward light, furnish some rays which go upwards and away in other directions from the objects to be illuminated, and are therefore relatively not useful. Furthermore, a bright source in the field of vision, causes an involuntary contraction of the pupil of the eye, which is equivalent to a decrease in illumination in so far as the eye is concerned. Hence, while reflectors or shades may at first seem to reduce the amount of light in the upper part of the room, their use actually increases the amount of light in a downward useful direction, and improves the "seeing" due to the better conditions which surround the eyes. The economic function of the reflector as contrasted to this easier conditions it affords the eyes, is to intercept the otherwise useless or comparatively useless rays which do not ordinarily reach the work, and to reflect them in a useful direction. In performing this function, there is a choice through the design of the reflector, in the manner of distributing the light so as to make the illumination on the floor space uniform with certain spacing distances and mounting heights as previously mentioned.

Avoiding Dark Spots.—With the use of lamps for which a large variety of reflectors is available, the proper reflector should therefore be chosen so as to give the desired distribution of light. In other cases, as in the use of the gas or electric arc lamps, where the globe or reflector is usually a fixed part of the lamp, care must be exercised to space the lamps at sufficiently close intervals to insure uniformity of the illumination, that is, a freedom from the relatively dark spaces which exist between lamps when spaced too far apart.

Light Interiors.—With a light ceiling, the reflection of that part of the light which passes through a glass reflector to the ceiling, and which is added to the light thrown downward from the under surface of the reflector, is a factor in building up the intensity of the illumination on the working surface. *Great importance is therefore attached to light interior colours, especially on ceilings and the upper portions of walls, both in reinforcing the direct illumination, and in giving diffusion, which in turn adds to the amount of light received on the side of a piece of work. It should also be stated that the intensity of the light from bare overhead lamps when measured on the working surface may be increased by as much as* 60 *per cent. through the use of efficient reflectors.* This is due to the utilization of the horizontal rays of light as previously stated, which predominate in the bare lamp, whereas the most effective light in factory and mill work is apt to be that which is directed downward.

Glass and Metal Reflectors Compared.—The question is sometimes raised as to the use of glass reflectors in connection with lamps for factory and mill lighting. This question is largely one of economy and maintenance, and it may be answered either in an off-hand way or on a basis of practical experience with both types.

In large installations of small units there has been an effort to establish the merits of glass and of metal reflectors, by equipping lamps in adjacent bays with glass reflectors in one case and with metal reflectors in the other. It has been found almost invariably that if the choice is left to the workmen and superintendents, glass reflectors will be given preference over metal, mainly on account of the added cheerfulness they produce. If, therefore, the first cost and maintenance expense of the glass reflectors is practically the same as with metal, then glass may be employed to advantage.

Reflector Efficiency.—Glass reflectors on the market are capable of producing an amount of illumination equal and even greater in some cases than that produced by the best metal reflectors, and even if the first cost is somewhat higher, the added advantage of glass as opposed to metal is usually sufficient to make the small difference in cost a negligible item. This factor is all the more noticeable when one considers that the reflector itself is a small part of the total cost connected with the wiring or piping of the lamp and its reflector.

Pierced metal reflectors are also available. These are designed with small openings at the upper portion of the metal so that the reflector may give the same distribution characteristics as a given glass reflector, thus affording a suitable metal reflector for use where glass may be objectionable. Some of the advantages of the pierced metal reflector are that it is unbreakable and that accumulations of dust on the outer surface do not decrease the efficiency. It is also true that the light which passes through the openings in this reflector to the ceiling cannot be diminished by dust on the outer surface as in the case of glass reflectors. (This type of reflector is shown in Fig. 8 under the main line shafting.)

Reflector Maintenance.—Regarding the maintenance of glass reflectors under rough factory and mill conditions, it may be stated that glass reflectors are used quite widely with almost a negligible increase due to breakage. Thus, out of the total maintenance cost in one representative installation, it was found that the charges were proportioned as follows:

Renewals, cost of lamps (tungsten)	75 per cent.
Renewals, broken glass reflectors	3 per cent.
Labour, making renewals and changing reflectors for washing	16 per cent.
Labour, reflector washing ..	2 per cent.
Additional indirect charges ..	4 per cent.
Total	100 per cent.

Points to Consider.—Reflectors will not be classified here from the commercial standpoint, but the following items should be given consideration in the selection of the type of reflector for factory or mill use.

1. Utilisation efficiency: how much does the reflector contribute to the effective illumination on the work?
2. The effect in reducing glare.
3. Natural deterioration with age through accumulations of dust and dirt.
4. Ease in handling and uniformity of manufacture.
5. Physical strength and the absence of projections which may increase the breakage in case of glass reflectors.

A study of the various reflectors on the market with the aid of these items as a basis, will determine what reflectors are best adapted to given conditions. Regarding the third item in the foregoing list, it may be stated that under comparative tests in service, the accumulations of dust and dirt on glass reflectors do not seem to be any greater than the coating of dirt which accumulates on the inside of a metal reflector in the same length of time.

Section XII. Side Light Important in Some Factory and Mill Operations.—It has been customary in many cases to measure the effectiveness of illumination in terms of the vertically downward component of the light. This method has ignored the value of side components in relation to vertical surfaces and openings in the side of the work. It is sometimes more necessary to light the side of the machine or the side of a piece of work than the horizontal surface. If, then, in designing a factory or mill lighting system, the prime object is the production of the greatest amount of downward illumination, it may happen that the side component is so small that the sides of machinery or of work are inadequately lighted.

Two Ways to Secure Side Light.—Experience indicates that there are two general ways in which to secure adequate side lighting. One of these methods is to lower the lamps, and the other is to use broader distributing reflectors than are called for by the rules which consider uniformity of the downward illumination only. Side walls or other reflecting surfaces will modify the results. Thus, after the determination of a certain type of reflector for producing uniform vertically downward illumination, it may be found that more side light is necessary, and this extra side component may, as stated, usually be secured by selecting a somewhat more distributing reflector. Broader distributing reflectors are apt to result in less downward illumination and will sometimes call for larger lamps than found necessary by preliminary calculations.

Practical Case.—As an illustration, in a certain lighting system a vertically downward intensity of about 3 foot-candles was deemed sufficient for the work involved. Measurements and observations showed that the side light was insufficient. In this particular installation it was found necessary to produce a vertically downward intensity of about 5 foot-candles on the average in order to secure an intensity of about 2 foot-candles on the side of the work, and also to use a somewhat broader distributing reflector than at first chosen. Two foot-candles on the sides of the work were sufficient in this case where bench work and work in the vice on small machine parts were conducted.

Keeping the Lamps High.—It is recommended that the lamps be mounted near the ceiling in all reasonable cases where side light is necessary, and that the side light be increased, *not by lowering the lamps*, but through the medium of broader distributing reflectors and larger lamps, if required. This attitude is taken on account of the glare which results when lamps are mounted too close to the work, a feature most noticeable in the absence of a reflector or where glass reflectors are used.

Section XIII. Maintenance.—The importance of system in the upkeep of natural and artificial lighting equipment may not appeal to every reader at the outset, but a consideration of the points involved will indicate that neglect of such work is apt to result in excessive losses of otherwise useful light.

Windows.—Factory and mill windows become covered in time with dirt, and produce greatly decreased values of natural light in consequence. These losses may easily be great enough to affect the workmen seriously, and to necessitate the use of artificial light at times when otherwise it would not be required. Dark surroundings also increase the likelihood of accidents. Regular window cleaning should therefore be a part of the routine of every factory and mill building or group of buildings.

Lamps.—Carbon filament, mercury vapour, gas mantle and tungsten lamps burn out or break, globes and reflectors become soiled, and the various other items of deterioration take place so gradually that in many cases they are given no special concern in the practical economy of the shop. Moreover, it is hardly necessary to mention the fact that often lighting systems are allowed to deteriorate to an extreme point and nothing is done unless complaints come in from employees after the lighting facilities here and there throughout the shop have become so poor that work has to be discontinued temporarily. The losses of time from such circumstances, when added up throughout a year, are more than likely to exceed the expense of systematic attention to such maintenance items in advance.

Overhead System.—Furthermore, with modern methods where the lamps are usually mounted overhead rather than close to each machine, the importance of relieving the workmen from any care of the lamps and placing it in the hands of a maintenance department is even greater than has been the case in the past, particularly in large plants. In one large factory all burned-out lamps are renewed each day except Saturday and Sunday, these renewals being based on a daily inspection of every lamp to ascertain whether or not it is in working condition.

Lamp Renewals.—It is found that the renewals are considerably greater on Monday than on any other day of the week, this increase being due to renewals not given attention on the two preceding days. Obviously, therefore, a continued neglect of the inspection and renewal of these lamps would soon result not only in inferior lighting conditions, but to large losses of time for the employees, not to speak of the annoyance involved.

Reflector Cleaning.—Serious loss of light may occur when globes and reflectors are allowed to go for long periods without cleaning.

In one particular case, which is a typical one, the loss of light at the end of the four month interval, amounted to about 50 per cent. The cost of electrical energy in this shop was such that the loss of light during the four months amounted to about 12 cents, while the total cost of taking down, washing, and replacing this reflector amounted to about 3 cents. The economy of a fairly frequent attention to cleaning of such reflectors is at once apparent, even if the improved condition of the light in itself be ignored.

The examples just given, in the one case associated with the renewals of the lamps, in the other with the washing of the reflectors, will serve to illustrate the class of upkeep problems which are involved in shop lighting. The most forcible emphasis is applicable to the idea that system may properly be called a first step towards success in this line of maintenance work.

A Method of Inspection and Maintenance.—In one large factory a regularly developed method of inspection and renewals is employed. As an example, the method as applied to several thousand tungsten lamps, which are in service in the various buildings, will be described. All the lamps are inspected once per day, except Saturday and Sunday. A regular route is followed by the inspector, and all burned-out lamps, broken switches, loose fuses, and similar items are noted. Careful observation is also made of reflectors which appear to need washing and any other points which might affect the efficiency of the system, after which a report is made up about noon and promptly sent to the maintenance department to permit all renewals and repairs to be made before night. In this manner the lamps are well maintained from day to day.

Marking Columns.—To facilitate this renewal work, it has been found advantageous to mark all columns through this shop. The inspector is thus enabled to indicate clearly the location of each burned out lamp and the renewal man to locate it without delay. It is helpful now and then in like manner to have the inspector note the unnecessary lamps found burning when artificial light is not required. If lamps are found burning at such times, a note sent to the head of the department calling attention to the matter, is usually sufficient to remedy the difficulty.

Noting Soiled Reflectors.—As a check on a regular cleaning schedule, the inspector should note all reflectors in need of cleaning. The frequency of each cleaning will depend on the rate of deterioration due to the settlement of dirt on the surface of the glass or metal and also on the surface of lamps, and the fact should be kept in mind that the amount of dirt on a reflector is nearly always deceptive, that is, reflectors which have suffered a large deterioration in efficiency due to dirt often appear fairly clean, and for this reason it is best to increase the frequency of cleaning somewhat over that which seems sufficient from observation, particularly in view of the fact that tests indicate large reductions of light from apparently small accumulations of dust and dirt.

A Method of Washing.—In the factory just referred to, all reflectors are removed to a central washing point. Where the number of reflectors to be hauled is large, a truck is used. Often, however, where only a small number of reflectors is to be transported, small hand racks, devised for the purpose, are employed. When an installation is in need of washing, the scheme is to haul sufficient clean reflectors to the location in question. The soiled reflectors are then taken down and clean ones immediately put into place, after which the soiled reflectors are removed to the central washing point, washed and put into stock for the next location.

Section XIV. Expert Assistance Suggested.—The advantages of securing expert assistance in dealing with illumination is strongly emphasised. The points which come up for solution are complex and require, in many cases, the judgment of one who has had wide experience in the lighting field. In particular, anyone who undertakes to adopt any part or all of these suggestions, will do well to secure the co-operation of a lighting expert capable of interpreting the legislative articles and of advising in a constructive manner.

Section XV. Other Features of Eye Protection.—Care is urged on the part of those responsible for the health and welfare of employees to see that adequate eye protection is afforded in all operations which are apt to cause injury to eyesight, if such protection is neglected. As typical of such other causes of danger to eyesight, arc welding may be mentioned, where the operator, according to accepted practice, must wear a helmet serving as an eye shield as well as a shield for the face and head in general. *Protective glasses for this purpose should not be judged as to their protective properties by mere visual inspection. They should, however, be analysed for their spectral transmission of invisible radiation.* Protective measures should also be taken to prevent on-lookers from being unduly exposed to such eye dangers, by enclosing the welding operations with suitable partitions. These general remarks apply with equal force from the standpoint of those handling the operations to such other cases as the testing of arc lamps, inspection of hot metal, and similar cases.

Section XVI. Auxiliary Systems for Safety.—The auxiliary system of lighting called for in Article XI of the Code, is a safety first precaution which is insisted upon in a large proportion of the 1,200 buildings coming under the control of the Bureau of Water Supply, Gas and Electricity in New York City, particularly such buildings as are occupied by large numbers of people. The same precaution is now observed by the Bell Telephone Company's offices fairly generally throughout the country, also by a large number of private manufacturers and by local ordinances compelling all types of amusement places to take this precaution.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

EFESCA LANTERNS FOR HALF-WATT AND VACUUM TUNGSTEN LAMPS.

THIS new catalogue, issued by **Messrs. Falk, Stadelmann and Co., Ltd.** (839-87, Farringdon Road, London, E.C.), contains particulars of a great variety of lanterns.

We notice several other useful types for interior lighting, for example, the "Bodmin," which appears to cover the filament very completely, and would no doubt give a useful downward illumination. Another attractive model is the "Burnley," in which the globe is mounted on a pedestal, suitable for placing on posts or pillars.

A very considerable proportion of the lanterns shown utilise clear globes for half-watt lamps. Although public taste has no doubt set the standard in this respect in the past we hope that after the war experience of present conditions will induce people to be satisfied with a more subdued system of lighting, thus encouraging a more general use of diffusing globes and reflectors.

A page is devoted to the Holophane E, I, and F, industrial units, and the compilers have tabulated the matter as regards price, spacing and illumination provided in a very convenient and serviceable way. It is worthy of notice that these complete data are only given for the Holophane units. We hope that in the future this practice will become more general.

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THE LIGHTING OF A LARGE SHIPYARD OFFICE.

THE three illustrations on this and the opposite page show the system of lighting supplied by the British Thomson-Houston Co. Ltd. through the Newcastle-on-Tyne Electric Supply Co. Ltd., for the new offices of Sir W. G. Armstrong Whitworth & Co. Ltd. (Wallsend-on-Tyne). It is stated that no fewer than 450 lighting points are used in this scheme, and we understand that it is the first office installation in the Newcastle district to be equipped throughout with Eye-Rest and semi-indirect fittings.

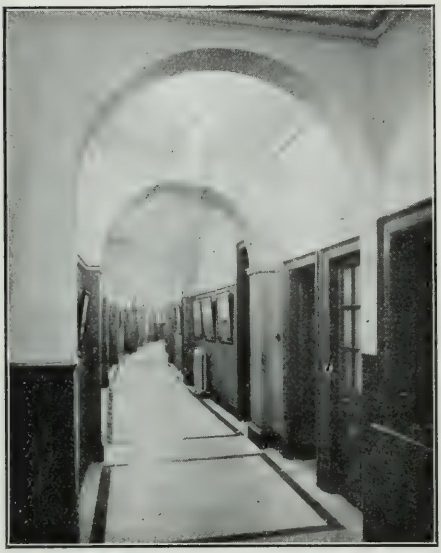


FIG. 1.—Corridor lighting at Sir W. G. Armstrong Whitworth & Co., Ltd., Newcastle-on-Tyne.

Fig. 1 shows the system of corridor lighting. The passages are arranged in a curve so that some thought is required in order to space the lighting units conveniently and at the same time to obtain uniform and adequate illumination. The problem has been met by the use of small spheres of ribbed Alabas glass.

In Fig. 2 we have an example of the system of lighting in the tracing and general offices, where semi-indirect fittings are employed. With the indirect system the source of light is of course completely hidden, and for this reason many have expressed the view that there is "something wanting" in the effect. To meet this objection one may employ semi-indirect fittings of the type shown in Fig. 2, which can be mounted close to the ceiling and are therefore useful in cases where it is desired to get an even illumination over the room, and to keep the lamps high up out of the direct range of view. In the general offices 300-watt gas filled lamps are used, in the tracing office similar lamps of 200-watt consumption.

Another variety of semi-indirect fittings is shown in operation in the Directors' Office (Fig. 3). This apartment is lighted by two "Eye-Rest" pendants, with 24 in. luminous panelled composition bowls, each fitted with two 100-watt Mazda lamps. This fitting is really a modification of the Eye-Rest Indirect unit, the lower portion of the bowl being of white or coloured glass instead of being opaque. No alteration has been made in the internal equipment of the bowl, with the exception that a lamp of quite small candlepower, enclosed within a diffusing globe, lights up the lower translucent portion, thus removing the dark effect of the indirect system, without prejudicing the distribution of light. Bowls of this class can be supplied with glass of special colours, selected in order to harmonise with the general scheme of decoration of the room. The construction of these units is interesting, the principle apparently being to regard the light from the supplementary small lamp as serving simply to produce the desired luminous effect over the lower portion of the bowl, without apparently contributing any very appreciable direct lighting element to the illumination; in this respect the system is somewhat different from semi-indirect methods in which the direct downward component plays a considerable part in the illumination, and the shadow conditions would presumably approach very near to those obtained with pure indirect lighting.

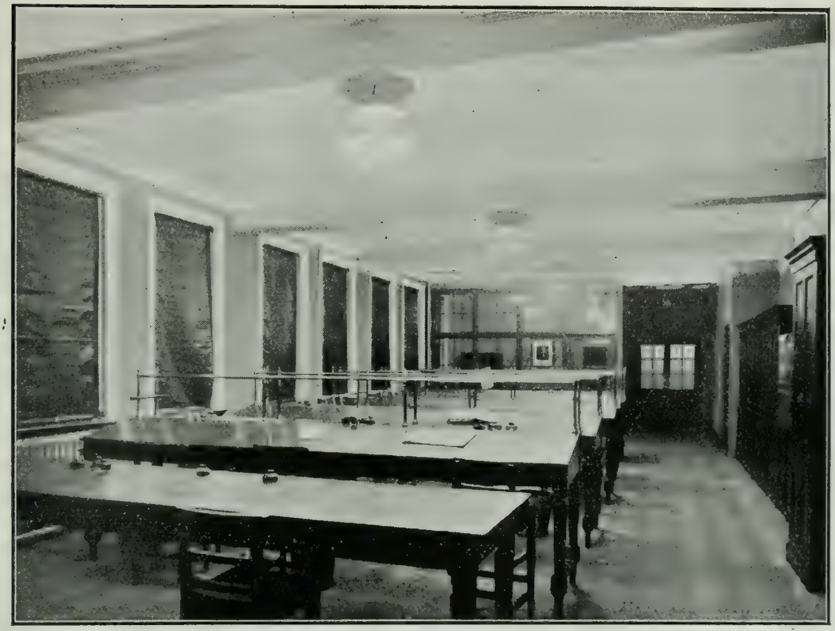


FIG. 2.—Semi-indirect lighting in the General Office of Sir W. G. Armstrong Whitworth & Co., Ltd., Newcastle-on-Tyne.

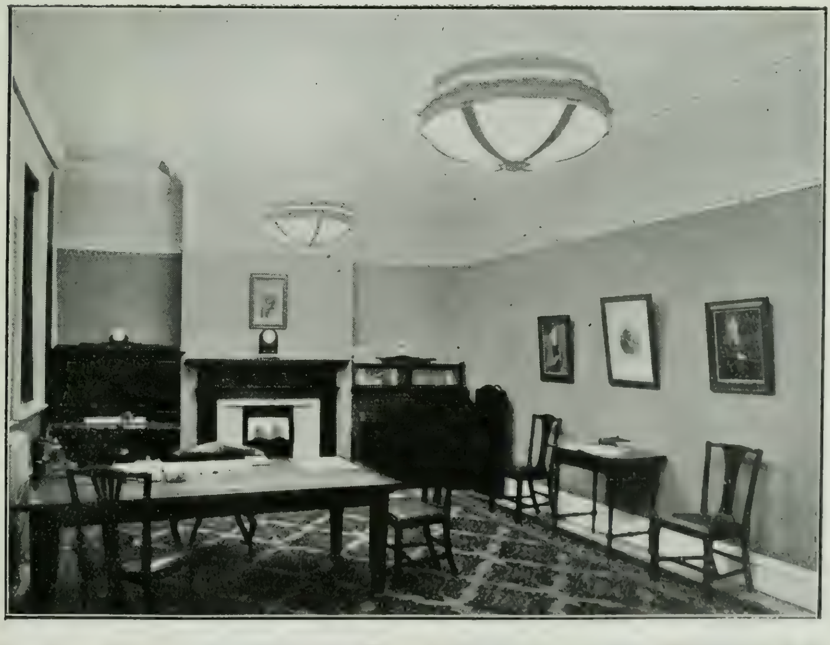


FIG. 3.—Lighting of the Directors' Office of Sir W. G. Armstrong Whitworth & Co., Ltd., Newcastle-on- Tyne, with semi-indirect composition bowls.

THE OSRAM AXIAL LAMP.

THE **General Electric Co., Ltd.** (67, Queen Victoria Street, E.C.) have recently issued a new type of Osram lamp (the Osram "Axial" lamp) which is stated to have special advantages in cases where a strong light must be concentrated over a small area. The filament is made of drawn tungsten wire wound in the helix of very small diameter, and arrange within a comparatively small space. The upper half of the bulb is covered by a conical opal reflector, and by this means an exceptionally strong downward illumination is obtained. It is recognised that the concentrating power of any reflector depends materially on the dimensions of the filament, and no doubt the compact nature of the filament in this case is instrumental in assisting the accentuation of the light in the desired direction.

The lamp is expected to be particularly useful for lighting desks, machine tools, showcases, shop windows, etc., as well as for fine work such as jewellery, watch and clock-making, etc.

—o—

A USEFUL METHOD OF GIVING WARNING AGAINST ZEPPELIN RAIDS.

During the last few months there has been much discussion on the best means of warning people of the approach of Zeppelins. Obviously the best method would be one which gave adequate warning to every householder but could not be heard or seen by hostile aircraft.

According to the *Journal of Gas Lighting*, in one of the cities in Scotland the warning was recently conveyed from the central electric supply station by producing a temporary fall in voltage, thus causing the electric lamps to glow a dull red. It is contemplated that a similar method may be applied in connection with the gas lighting, the proposal being that the pressure in the mains should first be reduced and then, when the householders have been warned by the diminution in light to turn off all the burners, the supply of gas should be cut off completely. It appears, however, that even this method might be attended with danger, and the subject is being further considered.

—o—

THE EMPLOYMENT OF WOMEN.

An Appeal to Employers has been issued jointly by the Home Secretary and the Board of Trade, pointing out the need for special measures to replace by women the men now being called up for the Army.

"There is one source, and one only," it is pointed out, "from which the shortage can be made good—that is, the great body of women who are at present unoccupied or engaged in work not of an essential character. . . . We appeal, therefore, on behalf of the Government to every employer who is finding his business threatened with diminished productivity through the loss of men, not to accept such diminution as an inevitable consequence of the war, but to make every possible effort to maintain his production by using women, whether in direct substitution for the men who have been withdrawn, or by some subdivision or rearrangement of his work."

The Home Office and the Board of Trade are prepared to give employers all the help in their power in taking this course, and a special Advisory Committee has been appointed to inquire into the subject.

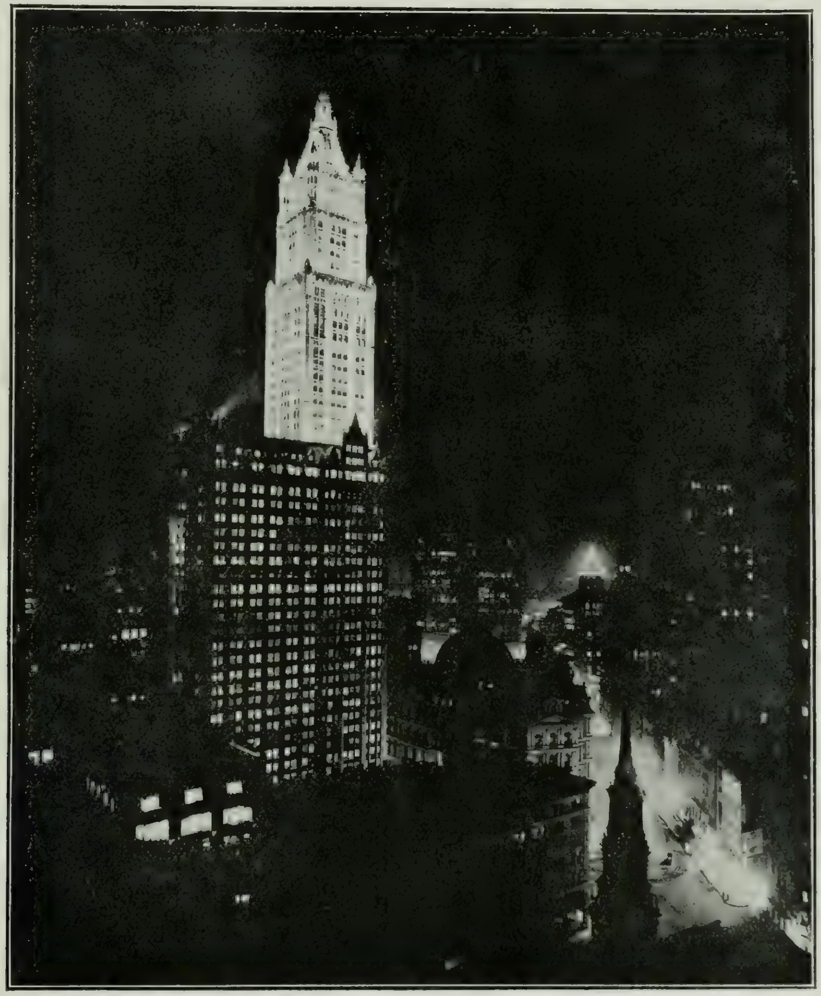
—o—

HIGH SPEED STEEL SCRAP.

Arrangements have been made by the Ministry of Munitions whereby the makers of High Speed Steel will take back all scrap, short ends, &c., at uniform prices, namely, 5d. per lb. for turnings; 6d. per lb. for bar ends, delivered steelmakers' works.

Such scrap should preferably be returned to the manufacturers who supplied the original steel, and should be free from all foreign substance, particularly other kinds of steel. According to the Defence of the Realm Regulations, it is illegal to dispose of High Speed Steel except through authorised channels, and users should, therefore, adopt the above arrangement in every case.

THE LIGHTING OF THE WOOLWORTH BUILDING, NEW YORK CITY.



In our February issue (p. 74), a reference was made to the large Woolworth building in New York, which is stated to be piped throughout for gas. We are informed, however, that this building, while piped for gas, is at present lighted both inside and outside by Mazda electric lamps, and we are reproducing a photograph kindly sent us by the National Lamp Works of Cleveland, Ohio, U.S.A., showing the appearance of the building by night.

The way in which the strongly illuminated tower "stands out" is most striking, and when the restoration of peace enables us in this country to turn our attention to decorative aspects of exterior lighting, this method of illuminating buildings by concealed lamps well deserves consideration. In this case the outside lighting is effected by six hundred 250-watt Mazda lamps in projectors, whose action can be clearly seen in the photograph.

This installation is interesting as an example of modern spectacular exterior lighting, and the photograph is certainly one of the best representations of such night-effects that have come before our notice.

REVIEWS OF BOOKS.*

Hygienic Conditions of Illumination in Workshops of the Women's Garment Industry, by J. W. Schereschewsky and D. H. Tuck. (United States Public Health Service Treasury Dept., Washington ; Public Health Bulletin, No. 71, *May* 1915.)

THIS Bulletin, which forms one of the series on "Studies in Vocational Diseases," was issued in May, 1915. In view of the recent Report of the Home Office Committee on Factory Lighting in this country, it is gratifying to see that this subject has been studied very closely by the United States Public Health Service. The Bulletin contains two distinct sections, the first dealing generally with the health of garment workers, the second devoted entirely to lighting conditions in this trade. The investigations into the bodily condition of the workers, their habits, and the defects possibly engendered by their occupation are remarkably complete, and it is noteworthy that among the defects noted, the cases of defective vision formed 69 per cent., while 50 per cent. suffered from results of faulty posture (a condition which, as has been shown, may quite conceivably be accentuated or even produced by wrong shadow conditions and imperfect illumination).

The section on lighting occupies about 125 pages. Detailed tests of the illumination, diagrams showing the correct and incorrect positions of benches with regard to the light, and particulars of the reflectors suggested for artificial lighting, together with polar curves, are furnished. A complete photometric survey was made of 34 shops.

Among the practical suggestions for natural and artificial illumination, a working illumination of 5—7 foot-candles is recommended (partly on consideration of the report on school lighting presented by the Joint Committee of the Illuminating Engineering Society in London in 1914) ; due emphasis is placed on avoidance of glare and the use of light surroundings in workrooms. We hope to deal more fully with this report shortly. Meantime it is of interest to put on record a most valuable piece of work.

——o——

The Excess Profits Duty and Profits of Controlled Establishments, by Spicer and Pegler, Chartered Accountants. (H. Foulks, Lynch and Co., 61, *Watling Street, E.C.* 1916. 6*s. net.*)

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* To some of these publications we hope to refer more fully shortly.

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THE INDUSTRIAL OUTLOOK AND ITS RELATION TO THE BRITISH GAS INDUSTRY.

A striking address on the above subject was recently delivered by Mr. H. M. Thornton before the Society of British Gas Industries at their Eleventh Annual Meeting.

The lecturer spoke of the need for continual and combined national effort. " State aid for industry by means of an extension of the Commercial Branch of the Board of Trade, that is to say, industrial administration by business men on business lines ; improved relations between Capital and Labour ; a revision of our Educational System in the light of new requirements, and the establishment of schemes for industrial research as it is known in America," were among the many suggestions brought forward.

Special reference was made to the part played by the gas industry in aiding the production of munitions of war. Gas industries undertakings, Mr. Thornton remarked, were united in doing their utmost to promote the engineering and other conditions essential to the supply of cheap gas, which would be one of the most important considerations in coming years.

One factor of great importance in this connection is the development and sale of residual products, and gas undertakings are doing all they can by research to bring about progress in this respect.

Naturally, too, there are great opportunities in the direction of discovering new opportunities for the use of gas, and there are still many cases in which gas is being employed in the crudest manner possible, without efficiency and without economy. At the present time it is estimated that only 15 million tons of coal are used in the gas works of the United Kingdom, as compared with 100 million tons consumed (and their valuable residual products utterly lost) ; there are thus great opportunities for further development.

Mr. Thornton referred to the system of industrial research scholarships now in operation in the Universities of Pittsburg and Kansas, and recalled that the Society of British Gas Industries had been instrumental in founding the Livesey Chair at the Leeds University, which was already doing useful work.

Another question of great importance was the utilisation of mineral products in the Empire. Owing to past shortsightedness in this matter, the supplies of zinc and nickel, both invaluable for war-purposes, had been exploited on the Continent instead of being developed within the British possessions. Another instance was furnished by the deposits of monozite sand, essential for the manufacture of thorium nitrate for mantles, which, however, owing to the enterprise of the Foreign Office, was now fully at the disposal of this country.

Finally, an appeal was made for preserving the health of the worker. Proper housing conditions, cheap and speedy means of conveyance of employees to and from works or factory, and the provision of industrial canteens supplying meals at moderate prices are all matters which cannot be neglected if the workers' efficiency is to be maintained at its highest level, and the Ministry of Munitions have welcomed and encouraged all attempts that have been made in these directions.

The
ILLUMINATING
ENGINEER

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

Edited by
LEON GASTER

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EDITORIAL.

Research in Illuminating Engineering.

On pages 167–177 we give an account of the proceedings at the Annual Meeting of the Illuminating Engineering Society on May 9th, at which the usual Report of the Council was presented. In spite of the inevitable and growing difficulties arising through the war, the Society has fortunately been able to carry on its work with undiminished activity. Meetings have again been devoted to subjects of special interest at the present time, and, in several cases, have been useful in eliciting fruitful suggestions for further work. Some of these suggestions are crystallised in the Report presented by the special Research Committee.

It will be recalled that this Committee was announced shortly before the outbreak of war, but it was found at that time impracticable to proceed with the investigations. But at the present time there appears to be an opportunity for useful work, especially in view of the growing appreciation of the value of industrial research and the various steps that are now being taken for the organisation of scientific investigation. As previously mentioned, one of the most important steps taken in this connection has been the formation of the Committee of the Privy Council for the Organisation of Scientific and Industrial Research, and we are glad to note, from several bulletins that have been issued, that a considerable amount of useful work has already been initiated.

Accordingly the Illuminating Engineering Society, in common with many other scientific and technical institutions, has been considering how the efforts of its members can best be applied in experimental work, and the first result is the Report which appears on pp. 172–177 in this number. The Report is concluded by an elaborate list of subjects for investigation. It was thought desirable to make this list as complete as possible, with a view to showing how wide is the ground to be covered, and how many are the opportunities for experiments which may be followed up in the future. Naturally there are many matters that will have to be postponed at the present moment, and it is proposed to concentrate on several researches, such as the investigation of illuminating glassware, which calls for immediate effort. While it may truly be said that the difficulties of initiating such researches are accentuated by the large number of members absent in the Forces or on special war-work, there can be no question that these matters deserve immediate attention, and should not be relegated to the period after the war. We hope, however, that the assistance of members will be freely offered, in spite of the pressing demands on their time, and that the problems involved will be considerably simplified by the co-operation of other societies. In some cases in which a considerable amount of experimenting will require to be done, adequate financial support will be required, but in view of the direct industrial importance of the matters to be considered it will doubtless be forthcoming.

While referring to this matter, we should also like to draw attention to one other point in the Annual Report,—the need for increased membership in order to carry on satisfactorily the work in hand. With such a programme as the Report on Research before them, members cannot fail to appreciate the usefulness of the movement. It is hoped, therefore, that they will do all in their power to assist by inducing friends to join and swell the existing membership.

It is also to be hoped that gas and electrical supply companies and other institutions which derive direct benefit from the work of the Society, will see their way to giving substantial support to its endeavours.

Technical Education and Industrial Research.

In a recent issue we gave a brief account of the proceeding at the meeting of the Circle of Scientific, Technical, and Trade Journalists on March 14th, at which a paper on " The Sphere of the Scientific and Technical Press in Relation to Technical Education and Industrial Research " was read by Dr. Wm. Garnett. In this issue we are reproducing Dr. Garnett's instructive paper *in extenso* (see pp. 153—166), and in the next number we hope to deal with the discussion at this and the subsequent meeting on May 16th.

The proceedings at this meeting were supplementary to those at the previous meeting of the Circle. An account of some of the recent proposals for the organisation of scientific work and the improvement of technical education was presented, and Mr. Gerald Lightfoot, who attended in the unavoidable absence of Mr. Hughes, the Prime Minister of Australia, gave an account of the comprehensive scheme for the establishment of a National Institute of Science and Industry in Australia—a matter which was also dealt with by the Right Hon. Andrew Fisher in his speech at the Annual Meeting of the British Science Guild on the 17th inst. Among others who took part in the discussion may be mentioned the Right Hon. Arthur Dyke Acland, Sir John Cockburn, and Professor R. A. Gregory.

During the past few months the constant attention given to the subject of scientific and industrial research by various committees and institutions has been an encouraging sign, but it has become apparent that in order that these suggestions may crystallise into a coherent national scheme, a serious effort to promote the interchange of views, and to bring about co-operation between these various bodies will have to be made. A feature of the scheme explained by Mr. Lightfoot was the provision for a Bureau of Information to enable the constant exchange of information to take place and prevent overlapping of work, and the whole principle of the scheme is based upon co-operation and the subordination of various bodies to a central authoritative Council. In Australia the problem is doubtless simplified to some extent by the fact there are few existing important scientific bodies to be considered, and therefore the framework can be built up on a logical basis. In this country co-operation can only be brought about more slowly, and one of the most effective means of influencing public opinion in this direction is undoubtedly judicious discussion in the press. We take the opportunity to reproduce the following resolution, proposed by Dr. Wm. Garnett, seconded by Mr. E. J. P. Benn, and carried unanimously at the meeting of the Circle, which effectively crystallises its aims in this matter :—

That this Meeting urges upon the various Associations, Institutions, and Committees engaged in the consideration of Technical Education and Industrial Research the necessity for co-operating in order to present a National Scheme for the consideration of the Government.

That in any measures taken for the preparation and execution of such a National Scheme the co-operation of the Scientific and Technical Press should be secured.

That this meeting is of opinion that the Press should use its influence to encourage the Teaching of Science in Schools and Colleges of all grades, and to determine the proper position of science in Civil Service and other examinations, especially with reference to the influence of these examinations upon Education.

That in the meantime it is desirable that all possible support should be given by the Press and the Public to the work of the Advisory Council to the Committee of the Privy Council for the Organisation and Development of Scientific and Industrial Research, and that Industrial Associations should report to the Advisory Council on the facilities required for the conduct of Research in connection with their particular industries.

Sir Corbet Woodall.

During the past year several leading gas engineers have passed away. But a few weeks ago, at the Annual Meeting of the Illuminating Engineering Society, the Chairman referred in feeling terms to the loss of two valued Vice-Presidents, Mr. Edward Allen and Professor Vivian Lewes.

We have now to record with deep regret the death of Sir Corbet Woodall, a distinguished Honorary Life Member of the Society, who passed away on May 17th.

On page 180 there appears an appreciation of Sir Corbet Woodall from the pen of Mr. F. W. Goodenough, his friend and associate for many years. There is no need for us to enlarge upon his distinguished professional career, nor to recall the many professional honours and distinctions he received. But we would like to add our tribute to the gifts of intellect and personality which kindled the respect and admiration of all who knew Sir Corbet Woodall.

In the year 1912—1913 Sir Corbet Woodall occupied the Presidential Chair of the Institution of Gas Engineers, the Society of British Gas Industries, and the British Commercial Gas Association—a unique testimony to his rare combination of technical and administrative abilities. His high sense of duty prevented him from accepting positions unless he saw his way clear to render constant personal service, and his many duties at this period would doubtless have taxed the energies of a much younger man.

Sir Corbet was intimately associated with many advances in gas lighting which have profoundly influenced illumination in this country.

Yet, while continually encouraging technical advances in the manufacture and use of gas, he never failed to emphasise the human side—to insist that those engaged in the supply of gas were carrying out an important public service, and should do all in their power to earn the confidence of the consumer and the goodwill of the general public. His influence in this direction was manifested in the creation of the Sales Department of the Gas Light and Coke Co., and in the wise and far-sighted policy that have marked the educational campaign of the British Commercial Gas Association. In all things he was an enthusiast for co-operation, and his name will always be associated with the adoption of the great Co-partnership Scheme by the Gas Light and Coke Co. during his term of office.

Although his life was devoted to the service of the gas industry, Sir Corbet Woodall took a large-minded and enlightened view of other illuminants. No better example of his policy in this respect could be mentioned than the statesmanlike conception of the National Gas Congress and Exhibition, held at Shepherd's Bush in 1913. In presiding at the Inaugural Banquet he struck the note that was followed consistently throughout the Congress, when he said :—

> "I need hardly say that this is not an anti-electric, it is a pro-gas exhibition. We recognise that there is room and a place for both gas and electricity in the service of the community. We use electricity for certain purposes in our own works ; the electrician uses gas largely in his works for the making of cables, dynamos and lamps, while the consumer in many cases uses gas to produce electricity. The presence of so many among us to-day, who are at the head of both gas and electricity undertakings, is evidence of community of interests between the two."

In the death of Sir Corbet Woodall the gas industry loses a gifted engineer and a wise administrator, the Nation a great and representative Englishman, whose work will be remembered for many years to come.

LEON GASTER.

THE SPHERE OF THE SCIENTIFIC AND TECHNICAL PRESS IN RELATION TO TECHNICAL EDUCATION AND INDUSTRIAL RESEARCH.

At a meeting of the Scientific and Technical Circle of the Institute of Journalists, held in the Hall of the Institute of Journalists on Tuesday, March 14th, a discussion took place on "The Sphere of the Scientific and Technical Press in Relation to Technical Education and Industrial Research." Mr. L. Gaster, Chairman of the Circle presided.

In opening the prcoeedings the Chairman said :—

"To-night I have the pleasure of introducing to you two gentlemen who have made a special study of the subjects of Technical Education and Industrial Research, Dr. W. Garnett, late Educational Adviser to the London Council, and Mr. A. P. M. Fleming, who is associated with the Industrial Research Dept., of the British Westinghouse Co. Dr. Garnett, who has made a life-long study of the subject, surveys the whole question of the organisation of education from the broad industrial aspect. Mr. Fleming will tell us something of the development of industrial research in the United States and elsewhere, and discuss the application of these facts to industries in this country.

"To us, as scientific and technical journalists falls the duty of studying these questions and ascertaining as far as possible, how we can help in spreading a knowledge of the benefits of applied science and bringing about a better appreciation of the value of education in relation to our industrial life.

"It is common knowledge that the war has led us to examine our present position, and has showed that in many directions we do not yet possess the complete educational facilities which the scientific development of our industries demands. Industries depending on scientific principles cannot be built up suddenly, and steady persistent effort will be needed. Above all action in this respect must be preceded by deliberation and discussion. In the present disturbed condition of trade it is, perhaps, hardly possible to embark on any wide scheme of practical development, but, if we are to be ready when the war is over we must utilise the present period to marshall our resources, to enlist the support of all those who can do something to prepare for the future. In particular, a great deal can be done to prepare public opinion for what is coming, and to create a favourable atmosphere for the reception of definite proposals.

"It is here that the technical and scientific press can help. It may be necessary to create new educational centres and improved sources of scientific research. But the most immediate need is clearly to organise those resources which we already possess. The various learned and scientific societies throughout the country are already doing good work and our educational institutions and colleges are also considering these problems. But it is, perhaps, not sufficiently recognised that in the scientific and technical press there is available a most valuable channel for education, and a unique means of reaching manufacturers throughout the country. The technical journals throughout the country can each prepare the way in their respective trades and industries, but in order to do so they must themselves understand the practical possibilities of industrial research, and must be kept in touch with the progress in their respective fields.

"One thing I am confident the war has taught us; the need for better co-ordination of the efforts of scientific workers. We must consider how to link together the activities of all the various scientific societies, educational institutions and scientific and technical journals, and it may be that in the future we shall see some form of co-ordination of all these activities so that we may all be members of an army of workers in applied science, engaged in the development of our national industries."

The Chairman then called upon Dr. Garnett to read his paper (see pp. 154-166).

THE SPHERE OF THE SCIENTIFIC AND TECHNICAL PRESS IN RELATION TO TECHNICAL EDUCATION AND RESEARCH.

By Dr. William Garnett

(late Educational Adviser to the London County Council).

(Introduction to a discussion at a meeting of the Circle of Scientific, Technical and Trade Journalists held at the Hall of the Institute of Journalists, Tudor Street, Blackfriars, London, E.C., at 8 p.m. on Tuesday, March 14th, 1916.)

1. The Technical Instruction Acts and the Education Acts.

On May 1st, 1904, the day appointed under the Education (London) Act, 1903, the last trace of technical education was removed from the Statute Book of England. Although the Education Act of 1902 had come into operation in the provinces a year earlier, London remained under the Technical Instruction Acts, with their definitions of technical and manual instruction, and technical education to cover both, until "the appointed day," but since then we have had no statutory definition of technical education. In fact, there is not, and never has been, any statutory definition of education itself. We must regard it as a primary conception, like time and space, which everybody is supposed to understand but no one can define in terms of things simpler than itself. The repeal of these definitions, with all the restrictions they implied, greatly increased the powers of local education authorities, for it was no longer illegal to supply, or aid the supply of, instruction in the practice of any trade, industry or employment; a restriction introduced into the Technical Instruction Act by the Labour Party in 1889, which they themselves regretted when experience had given them confidence in the educational work done by the local authorities. Unfortunately, in London at any rate, it was not possible in 1904 to take full advantages of the freedom which the new Act offered in the direction of rendering further assistance to professional and trade education, because the transfer to the Council of the whole of the work of the School Board diverted attention to the administration and development of elementary education and the training and selection of teachers, with the organisation of secondary education as a means thereto; and technical education, for which the law now prescribed no exceptional treatment, had to experience a temporary check and bide its time for further rapid development.

2. Technical Education since 1904.

I do not mean that nothing has been done during the last twelve years for the benefit of industry, and especially scientific industry. The Imperial College would itself be sufficient answer to such a suggestion. Many trade schools have been established for women and some pre-apprenticeship schools of an essentially trade character have been provided for boys, while maintenance scholarships have been made tenable in both classes of schools; but we have not yet established systematic courses of training on carefully thought-out lines for the industrial statesman or leader of industry, the technical expert, the works manager, the workshop manager, the foreman, the precision worker or other highly skilled mechanic, including the superintendent of automatic or semi-automatic tools, and the machine minder. The war has taught us the need of an industrial army organised with its due proportion of officers, non-commissioned officers and men, all trained for the work they have to do. One great difficulty with which the Ministry of Munitions has had to cope has been the lack of precision workers, men who could work in hardened steel to an accuracy of one three-thousandth of an inch or less, and hereafter our engineering schools will have to adapt themselves to the requirements of the most up-to-date works.

3. Need for Practical Work in Schools.

But of far more importance than any technical detail is the development throughout our whole educational system of individual resourcefulness and self-reliance. These qualities are not produced by studying text-books, often written by authors who themselves have no first-hand knowledge of their subject, or by listening to oral teaching and reproducing it in an essay. Even the solution of mathematical problems, while it quickens a very useful type of intelligence, does not necessarily develop resourcefulness or self-reliance except on paper. Our educational system must aim at bringing children more into contact with *things*, from which the symbolic methods of the drawing office and the mathematical class-room, which are absolutely essential in their place, should naturally grow, as the young worker finds by experience that he needs their assistance. The Scout problem of lighting a fire in the open air with the use of not more than two matches develops more self-reliance than the mastery of all the facts in a text-book of geography or history. I am not depreciating these latter subjects ; I am only seeking for an illustration by comparison. I have often said that of the subjects I studied at school, Latin prose has, perhaps, been to me the most useful, not because I am ever called upon to write a Latin epigram, but because the practice of Latin prose developed the habit of examining carefully into the meaning of words and the best forms of expression, and much of my life has been spent among papers and Acts of Parliament, though my tastes would have led me into work of construction. Closely associated with self-reliance and resourcefulness is quickness of perception which is also developed by good scout training, but necessitates dealing with real things.

4. How Can the Press Help.

The first step which I think should be taken by the scientific and technical press to help the education of the country is to create a public opinion in favour of further developing in elementary and secondary schools the self-reliance and resourcefulness which spring from a conscious mastery of Nature through the successful performance of real pieces of work, and not their paper analogues. As things now are, self-reliance is learned mainly in the playing fields ; but much progress has been made in the last few years in the desired direction in the elementary schools. This is a reform which will affect the whole population. The next step is to endeavour to secure more systematic training for each of the classes of workers to which I have referred, and in particular to see that industrial statesmen study economics not less diligently than workshop appliances.

In order that the teaching of the schools should be more closely related to the practical problems of life it is essential that some of the teachers, whose tastes lie in that direction, should have greater opportunities than they at present enjoy of becoming acquainted with trade processes, not with a view to their becoming tradesmen, but in order that they may secure the interest of their pupils in questions bearing on trade work, and be in a position to point out the practical value of the school instruction in arithmetic, geometry, mechanics and elementary science. Elsewhere I have suggested that the two years' training college course should, in some cases, be supplemented by a third year in a polytechnic or other technical institute where trade classes are held ; so that the student, while working in the science laboratories, may have the opportunity of seeing practical work in a number of trades, and, perhaps, gaining a little experimental experience in some of them.

Moreover, apart from their indirect influence on the methods of teaching in elementary and secondary schools, scientific and technical journals can themselves act as a valuable educational agency by the dissemination of information and ideas on applied science and technical research in the industries with which they are in contact.

5. National Organisation of Industry.

In the February number of a trade journal, the *Watchmaker and Jeweler*, the Editor, Mr. W. A. Steward, remarks, after referring to the aerial struggle of the nations in "Locksley Hall":—

"It is not the poet who warns you now, but the business man, awakened from his lethargy and dreams of security. The trade war is to become something more than securing personal aggrandisement, it is to be waged as a matter of national strength, as a means of preventing another great war. Let our trade battalions find a leader who will organise them into army corps. . . . You cannot win wars by forming committees, neither can they be won by selfish individualism. The individual must be prepared to efface himself in order that the whole may be more and more."

So much for national organisation *versus* individual competition.

6. The Need for the Diffusion of Science.

The next point which I would urge, though it is somewhat outside the main subject of this paper, is the necessity for a more widespread distribution of scientific knowledge, not among scientific workers, but among the general public, including statesmen and civil servants. The teaching of science, like that of some other subjects, has become far too highly specialised. I have sat on a University Committee with a number of Professors discussing the subjects for matriculation where nearly all the members requested that their own subjects should not be included as they preferred that boys entering their classes from school should have no previous knowledge thereof in order that the boys might then be professionally trained from the start. When I was a school boy the Polytechnic in Regent Street was a place of very popular scientific entertainment, Pepper's Playbook of Science was an ordinary school prize, but more important than these were the popular lectures given in the School of Mines in Jermyn Street by such men as Huxley, Tyndall and Frankland, quite free to the public. Let us retain a strictly scientific course of training for the youth who is to make science his profession, as we provide professional courses for architects, engineers, lawyers, doctors and other professional men, but let us endeavour to secure that the educated public shall have such a general knowledge of the phenomena of Nature and of the more important manufacturing processes that Members of Parliament will cease to wonder whether we shall *ever* know why the moon appears to change her shape, and we shall not be told that lard has only just been discovered as a source of glycerine, that mineral oil from Galicia is equally useful for this purpose, that wool will take the place of cotton in the manufacture of nitro-cellulose for propellants, or that a cargo of phosphate has been seized lest it should be used by the enemy for the manufacture of phosgene gas. As far as I know, the only connection between phosphorus (the light producer) and phosgene (the product of light) is that the former emits a brilliant light when burned, and shines in the dark when exposed to air, while the latter is commonly made by exposing to sunlight a mixture of carbon monoxide and chlorine, the light causing the union of the gases.

In this connection very great services might be rendered by the press, not so much by the publication of scientific articles as by encouraging the resuscitation of what I may call popular science as part of a general education, both in school and after school days by suitable books and lectures. *Nature* has set a good example in this respect. Thirty years ago, before the coming of the kinematograph, when its precursor, the zoetrope, afforded the best example of moving pictures, audiences of several hundreds were common at scientific lectures, outside the Royal Institution. Now the classes of the Workers' Educational Association have partly taken the place of University Extension lectures. The classes are small, which is a good feature for systematic training and the encouragement of free discussion, but they are generally on social or economic questions, and science in its pure form or in its application to industry receives little attention outside the professional circle.

It was publicly stated some weeks ago that Lord Haldane once promised that if the Liberal Party came into power there should be a due proportion of scientific men in all Government offices. This result has not yet been brought about by the Commission on the Civil Service. Perhaps this is another field for the influence of the press, but it must always be borne in mind that in administrative work, where the dealing is with men rather than things, the student of the Humanities has a great advantage. Though I am pleading for a much more general knowledge of science among Civil Servants, I am not prepared to recommend that a large proportion of the Civil or Municipal Service should consist of scientific specialists who have made science their principal subject of study. There should be a small proportion of such scientific men in every Government office, selected according to the nature of the work of the department concerned; and a larger proportion in some departments. The Board of Trade, the Admiralty and the Ministry of Munitions, for example, require a great many scientific members on the staff, but as Government and Municipal offices are at present conducted the success of an administrative officer depends not so much on his knowledge of the right thing to do in order to achieve the greatest advantages for the community as on his power of gauging what his superior officers, or Parliament, or his local authority, are prepared to permit him to do. The officer who proposes the course of action which other people are desiring to take, though they have not formulated their desire, succeeds in public life; the officer who studies things rather than character and proposes what is absolutely the best, but is a few years in advance of public opinion, is a failure in official life though he may live to see all his proposals carried out—by others. This goes far to explain the success in administrative work of the Oxford student of the Humanities and the advantages offered to him by the Civil Service examinations. The choice of convincing words and elegance of diction will, perhaps, complete the explanation. An examination for Class I., based mainly on science, would bring men to the top of the list who would afterwards be declared to be administrative failures. Sometimes, of course, the scientific man possesses also the power of gauging public opinion and the readiness to waive his scientific conclusions for the present. He may even be a member of the Fabian Society; but the power to quote Plato and Aristotle as authorities still counts.

7. The Case for Scientific Research.

After all that has recently been written on the subject there is no occasion this evening to recite the history of the application of science to industry in order to prove the desirability of encouraging industrial research. Few persons to-day will doubt that even the purely scientific investigator, if allowed suitable facilities for his work, and adequately assisted in its practical development, can afford very great aid to industry. Certainly we need not go back to the Davy safety lamp, or Faraday's discovery of the "magnetic spark," the origin of every electric generating station in the world to-day, when we have seen produced in the last few months the anti-gas helmet, which has been so effective in protecting the soldiers on the Western Front. Only a very short time ago a research student at Manchester, working for his M.Sc. degree, developed a method of enabling a generator to take a much greater over-load than had previously been possible, and within a year a rotary converter of 500 kilowatts capacity, was installed and working at the Salford Generating Station on his design. I have frequently contended that the phenomenal rate at which electrical engineering advanced during the early years of its recognition as a profession was due to the number of university men trained in mathematics and physics who took up the subject and to the facilities provided by educational laboratories. The experiments of Hertz, apparently of no practical value in their results, based on Maxwell's electromagnetic theory of light, which when enunciated by him in 1865 appeared to be not simply in the clouds but far above them, have, in the course of a few years, produced wireless telegraphy; but between the work of Hertz and a Marconi

Transatlantic station there has been an immense amount of patient labour which affords an illustration of what is sometimes required in the second stage of scientific research to which I shall presently refer more particularly.

8. The Advisory Council for Research.

I suppose that the appointment in July last by the Minister of Education of an Advisory Council for Research has been generally welcomed, except by those who think that the Scientific Societies ought to be able, of their own initiative, to create all the machinery required not only for the work needed in the department of each, but also for the joint action of several where industrial interests overlap. Provided that the Advisory Council is entrusted with the distribution of adequate funds and with powers sufficient to secure that its advice will be followed, and provided further that it does not attempt to do everything off its own bat, but fully utilises the services of all the scientific, professional and trade societies willing to co-operate in proposing subjects for investigation, selecting the institutions where the work can be carried out, choosing the workers and superintending the investigations, it may render services of extreme value. It is also important that the laboratories of universities, colleges and technical institutions should be utilised for organised research to the utmost extent compatible with the educational work for which these institutions were primarily founded, but when this is done it will be found that a great many new institutions will be required and must be established under the guidance of the Advisory Council, and, perhaps, to a great extent, through funds provided by Parliament, though much of the money required should be provided by the trades interested. The duties of the Advisory Council are thus set forth by the President of the Board of Education :—

"The Primary functions of the Advisory Council will be to advise the Committee of Council on :—

"(i.) Proposals for instituting specific researches ;

"(ii.) Proposals for establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades ;

"(iii.) The establishment and award of research studentships and Fellowships."

The President of the Board of Education states that there must be a single fund for the assistance of research for the Kingdom as a whole, under a single responsible Body. That Body is a Committee of the Privy Council comprising half-a-dozen Ministers of the Crown and certain non-official Members. It is nominally the function of the Advisory Council to advise this Committee, but, presumably, the main function of the Committee is to act as an intermediary between Parliament and the Advisory Council in connection with the appropriation of Parliamentary moneys.

Dr. Fleming, in his paper read before the Royal Society of Arts on February 9th, said : "This war is a war quite as much of chemists and engineers as of soldiers and sailors. Hence, from the point of view of national security alone, we must take steps to foster scientific investigation." The War Office, the Admiralty and the Ministry of Munitions have taken steps for the period of the war. For a permanent institution, the Government has established the Committee of Council, and the Advisory Council for Research. As in other cases the Committee of Council may, in course of time, be replaced by a new Ministry.

There are many men of science who deprecate any State interference with research, and Dr. Fleming is apparently one of these ; but in the paper already referred to he says : "No great enterprise can be carried out unless there is some degree of surrender of initiative and acceptance of direction from a higher command. To carry out this principle in scientific work it appears to me that we require to a fuller extent than we have it at present the system of scientific work done to order." Hitherto there has been no sign of the "higher command" coming from the Royal Society or from any combination of scientific societies. The British Association is almost the only body which has successfully attempted the organisation of research, and the time has come when the Government should take the matter in hand.

The main work for the Advisory Council is well indicated by another statement of Dr. Fleming: "If some men are to surrender initiative in their work, then others must give time and thought to planning the outlines of the scientific campaigns. We need not only the Regimental Officers, but the General Staff, if there is to be effective achievement." Another requirement is set forth by Dr. Fleming thus: "We have to formulate in precise detail the suggestions for future work, and bring them to the notice of those who may be able or willing to work them out." Herein the Advisory Council will need all the assistance which can be given to it by the scientific, professional and trade societies and the technical and scientific journals representing them, as well as by individual manufacturers and scientific experts.

There are two methods by which the Advisory Council may secure the necessary "touch" with industrial interests. The better of the two is the voluntary formation by the traders themselves of Associations or Committees to advise the Council and work in conjunction with it and, to some extent, under its guidance, while they themselves enjoy the full confidence of the trades they represent. The other method is the formation of Committees for particular trades or groups of trades by the Advisory Council itself which would invite leading members of an industry to form a Committee which would come between the Advisory Council and the Trade.

9. The Stages of Industrial Research.

Broadly speaking, the results of industrial research may be divided into two classes—those which relate to improvements in processes or appliances already widely used and those which introduce entirely new products or methods of manufacture, generally necessitating large capital expenditure before they can be commercially applied. To this distinction I shall have to refer later on. The work which is involved in developing the results of discoveries so as to render them successful when applied on a commercial scale varies in different cases as much as the character of the investigations which led to them, but in very many cases three stages may be recognised in the whole process:—

(1) *Inception.* The purely scientific investigation conducted in the research laboratory, frequently with no definite practical object beyond the desire on the part of the investigator to extend the boundaries of knowledge.

(2) *Adaptation and Standardisation.* The practical adaptation of the discovery to a manufacturing process on a small scale; the testing of the results and the removal of the difficulties which occur in practice; the standardisation of processes and parts.

(3) *Commercialisation.* The adaptation of apparatus and processes to manufacture on a commercial scale where cost of production is a prime factor.

As pointed out the other day by Sir Wm. Tilden, Britain and France have been prominent in Stage I. Germany's success has probably been largely due to her patient work in Stage II.

10. The College Laboratory.

Sometimes all three stages are carried out in the works purely in the interest of one firm; and in this case the public may in course of time purchase the goods but they will learn nothing about the investigation. Research conducted in this way will continue, but will not generally come under the purview of the Advisory Council or any public authority. For researches conducted with the aid of public money considerable provision is made for the first stage in the laboratories of university and technical institutions where professors and other teachers work with their students, both pre-graduate and post-graduate. Much of the students' work has purely an educational aim, providing training in methods of research which the student may afterwards apply with a more definite industrial object, but even such work may lead to results of great intrinsic value, as in the case of the Salford generator already mentioned. Work of this type is carried out by the research scholars appointed by the Commissioners of the 1851 Exhibition, and it is very desirable that the number of these research scholarships should be increased and that university graduates who are looking forward to occupying leading positions in industry should gain in this way some experience of the methods of research. But other investigations in the college laboratory may be conducted with the special object of solving some industrial problem. Many such investigations have been carried out since the commencement of the war for the Admiralty, the War Office and the Ministry of Munitions. In a schedule of such work prepared by certain universities I noticed more than a dozen items deleted by the Press Bureau, which appears in itself to be sufficient evidence of their value, while it also suggests to me the undesirability of talking about them. More research professors, more research scholars and more laboratory accommodation, with more liberal equipment, will undoubtedly be required if sufficient provision is to be made for Stage I., but the first step which should be taken by the Advisory Council is the preparation of a schedule showing all the existing provision in public educational institutions, the qualifications of the superintendents of the laboratories and their assistants, measured not by their degrees but by the original work they have done, and the number and status of the students assisting in original work. The schedule would include laboratories for all branches of engineering, chemistry, metallurgy, physics, botany, geology, bacteriology, and, perhaps, biology and physiology. Certainly the physiological laboratories have been called upon to undertake very important investigations in connection with the present war.

11. Work for Trade Societies.

Of the investigations conducted in these laboratories many would be initiated by the teachers in charge, others would be carried out on the recommendation of professional or trade associations, others again at the request of commercial firms, and some would be suggested by the Advisory Council itself. The work of the Advisory Council may be greatly relieved by trade associations, who will ascertain the facilities for research in their district and introduce the manufacturer to the superintendent of the laboratory, a suitable report being sent to the Advisory Council, but in some cases the Council must itself invite trade societies and professional institutions as well as private firms to bring directly to them problems requiring solution. In connection with the Research Fellowships established by the late Dr. Duncan in the United States, the manufacturing firms who provide the expenses of the Fellowships state the particular problems which they desire to be solved in the university laboratories, and offer facilities in their own works for any part of the investigation for which the university laboratories are less suitable. I am told by Mr. A. P. M. Fleming that most of the Fellows who have carried out these researches have entered the industries concerned.

There are those who urge that scientific research should be left entirely in the hands of scientific men and their associations without any interference on the part of a State-appointed committee. There is much to be said for the view that there should be no interference on the part of such a committee with research spontaneously undertaken by scientific workers, but for the discovery and solution of problems of industrial importance some machinery is required which will bring the manufacturers and scientific investigators into much closer association. It is the nature of this machinery on which opinions differ. I have indicated above the two forms which I think it might take.

12. Adaptation and Standardisation.

For the Second Stage, the facilities afforded by public institutions are less extensive than for Stage I. There are some technical institutes in which adequate provision is made, both for Stage I. and Stage II., except that if the institute is a monotechnic institute and not part of a much larger institution the co-operation of professors of other branches of science or technology is lacking. In the Leathersellers' College in Tower Bridge Road, skins can be tanned, dyed and dressed ready for market, and rendered quite as saleable as in a commercial leather works, but the output is necessarily very small. The College also possesses analytical and research laboratories designed to suit all the requirements of the director of the school, who has a very high reputation as an investigator of questions connected with the tanning and dressing of leathers. Similar conditions obtain in the tanning department of the University of Leeds under Professor Procter. The L.C.C. School of photo-engraving and lithography is equipped for research in photo-process work, and it can turn out blocks comparable with the best in the trade, but it is not in a position to take an order for a number of half-tone blocks to be delivered the same day. Here, as in the leather works, the output consists of distinct units and the processes are the same for a single skin or process block as for a thousand. This is not the case with pig-iron or sulphuric acid or soda crystals. In many of our manufactures the process must be carried out on a large scale, but even in some of these cases technical colleges are provided with the necessary equipment for Stage II. Steel manufacture is thus treated in the University of Sheffield and provision is made for some other branches of metallurgy in the Imperial College at South Kensington. Cotton spinning and weaving, calico printing and paper-making are treated on a commercial scale in the Manchester School of Technology, and the woollen industries in the University of Leeds, at Bradford and elsewhere. In these institutions there is provision for laboratory research, for manufacture on the commercial scale and for testing the results, mechanically and otherwise. In the engineering laboratories of all the higher institutions there is more or less adequate provision both for Stages I. and II., especially in connection with mechanical engineering, including " prime movers," and electrical engineering. Structural engineering cannot, of course, be carried out in the laboratory, for the small scale model has entirely different mechanical properties from those of the full scale structure. Geometrical and dynamical similarity are not governed by the same laws. In structural engineering the ordinary laboratory can do little more than test materials and fastenings.

But while for a very limited number of industries provision can be made, both for Stages I. and II. in the college laboratory and workshop, and in some there is no need for special experiments under Stage III., in many of the most important branches of work it is not possible to provide even for Stage II. in the college laboratory, and if it were possible it would be undesirable to take up the time of the professional staff with the supervision of the great amount of routine work which is often involved in what I have called " Adaptation and Standardisation." It is easy in a college laboratory to provide facilities for electrical experiments at high voltages, 20,000 or 30,000, or even 100,000 volts. It is only necessary to take precautions for the safety of the workers. But it is not possible in these institutions to provide large currents of, say, 3,000 or 5,000 amperes without great expense for very occasional use. Similarly, a metallurgical laboratory may be fitted up with hand apparatus for testing the malleability and ductility of metals and alloys, but a rolling mill for the preparation of plates and bars from which test pieces may be cut is a desideratum which, even on a very small scale, cannot be supplied to every metallurgical laboratory.

13. The National Physical Laboratory.

For standardising scientific apparatus and testing the physical properties of materials the institution *par excellence* is the National Physical Laboratory at Teddington. This laboratory, with its 250 skilled workers devoting their whole time to measurements, and processes antecedent to measurements, fills many a gap which previously existed in the facilities afforded for Stage II., at least as far as standardisation is concerned. The Laboratory comprises :—

A department for pyrometry, with electric furnaces working up to 3,500° C.

A department for the testing of thermometers, including clinical thermometers.

A special room for the testing of radium by a standard consisting of 21 milligrammes of radium chloride.

Apparatus for testing thermal conductivities and a laboratory for the examination of mineral oils.

A department for magnetic and electrical measurements, comprising apparatus for testing the magnetic properties of samples of iron and apparatus for measuring electric capacity and inductance at various frequencies.

A laboratory for wireless telegraphy, including a camera for photographing sparks up to 2,000,000 a second.

An electrical standardising laboratory with standard cells and apparatus for weighing electric currents and for measuring directly very small resistances.

An arrangement for testing compasses.

A department for testing watches clocks and chronometers at high, medium and low temperatures.

The optical department for testing sextants, theodolites, clinometers, telescopes, binoculars, spectacle lenses, photographic lenses and other photographic accessories, telescope object glasses and spectroscopes.

The department of electrotechnics, with facilities for working at high voltage, up to 100,000 volts, and with currents at low voltage, up to 6,000 amperes, including the testing of commercial and other measuring instruments.

A laboratory for photometry, with special reference to the testing of arc and glow lamps and determining the life of the latter.

A room for illustrating different methods of lighting, which was equipped for the Home Office Committee on Factory Lighting.

The very important department of metrology, with arrangements for measuring tapes or wires up to 50 metres, comparators for testing standards of length up to 4 metres, testing apparatus for gauges, &c., measuring to 0″·00001, apparatus for measuring all the features of a screw and for cutting standard screw threads, appliances for testing barometers and aneroids and for measuring to 1 part in 1,000,000 standards of mass from 1 gramme to 50 kilogrammes and apparatus for testing taxi-meters.

A laboratory for engineering tests and research, capable of testing materials in tension, compression or bending up to 100 tons. This laboratory also comprises apparatus for impact tests and for testing materials under rapid reversals of strain, up to 2,500 reversals per minute, apparatus for testing gauges up to a pressure of 24,000 lb. per square inch and testing water meters. Research apparatus has been fitted for several investigations of interest to engineers.

An aeronautical laboratory, with wind channels, whirling table for testing propellers, and two experimental towers 60 feet high with revolving platforms for exposing large models to the wind.

A special department for making up experimental road surfaces and testing them and the materials used in their construction.

The Wernher department of metallurgy and metallurgical chemistry, with very complete appliances for photomicrographic work, a foundry where large castings (2 or 3 tons) can be made, a testing laboratory, a furnace room, a rolling mill for alloys used in aeronautics, and chemical laboratories for steel analysis, the analysis of alloys, gas analysis, and for research work on road and aeronautical materials.

Last, but not least, is the William Froude tank, 550 feet long, with all its accessories for making and testing ships' models.

This schedule is very far from complete and is intended only to give an idea of the scope of the National Physical Laboratory.

14. Requirements for the Chemical Trades.

For the chemical trades and other trades dependent upon them we have nothing which quite corresponds to the National Physical Laboratory. Much has been said lately about the manufacture of optical glass, and I will not here repeat it. Primarily, this is a chemical industry though the conditions which the glass is desired to fulfil are those laid down by the designer of optical instruments and belong essentially to the department of physics. The glasses made can be tested at the National Physical Laboratory, and lately a small furnace for glass-making has been provided there, but we have no public institution adequately equipped with appliances for making the glass and for cutting and grinding it into plates, prisms and lenses. The Optical Institute, which it was proposed to establish in London, would have met the requirements of the optical instrument-maker both for Stage I. and

Stage II. A national Industrial Chemical Laboratory would have for its principal object the standardisation of chemical operations invented in the research laboratory, so as to ascertain precisely the conditions under which reactions take place most favourably and at the least cost, and the methods of securing a sufficient degree of purity in the product; but the great diversity of operations required in manufacturing chemistry will probably render it impossible to establish a single institution for chemistry corresponding to the National Physical Laboratory. In mechanics and physics it is possible to provide a set of apparatus capable of making nearly all the measurements likely to be required. A department of metrology, for instance, will suffice to measure linear dimensions of any materials for whatever purpose they may be used. Similarly a well-equipped electrical standardising department will deal with the electrical features of almost any appliance which may be submitted, but nearly every branch of manufacturing chemistry, when it has passed the laboratory stage, requires separate treatment. It is quite true that dyeing materials and high explosives have much in common in the basis of their composition, and it was the accidental explosion of a dyeing material, viz., picric acid, in Manchester, which gave the start to the manufacture of a number of high explosives; but the tests which have to be applied to dyes and to explosives are so widely different that there would be no point in dealing with them in the same institution. In chemistry, therefore, there is much to be said for the monotechnic institution, or the standardising laboratory which deals with a single group of trades such as dyes, explosives, artificial manures, mineral colours, oils and fats, cements, glass, pottery, drugs, rubber, fibres (including paper), flour, bread, and so on. The Society of Chemical Industry recognises 26 groups of chemical trades in their classification of inventions. It would be difficult for any single committee to keep even a general oversight over such multifarious institutions and processes, and therefore most of these standardising laboratories should be directly managed by the trades concerned. This, I know, brings us face to face with the greatest difficulty we are likely to have to meet, and it is that of the distribution of information. Chemists, beyond all other manufacturers perhaps, appear to believe in the policy of secrecy. Success in international competition implies unity of purpose and community of knowledge throughout the industrial army, and this further implies division of labour on an economic basis. Let knowledge be common and let each manufacturer do the work which he can do best and most economically. We may at least borrow this measure of co-operation from the Germans, and it is only in this way that we may hope to secure joint action in the maintenance of a standardising laboratory which shall be conducted in the interests of every member of a trade or group of trades, whether directly at the cost of the trades or subsidised by public money. Where trades are mainly local the laboratory should be in the same locality. If the press could help in uniting the members of the trades to take joint action in their common interest and that of the industry of the nation it would be doing most excellent work. Manufacturers would not be called upon to reveal secrets they already possess, or new secrets which they may themselves hereafter discover, but they should be persuaded that, as a rule, they will gain more than they will lose by sharing the knowledge acquired through combined industrial research.

Trade committees, either local or national, should be formed, whose business it should be in the first instance to ascertain what facilities already exist in the universities or technical institutes for conducting investigations connected with their trade, and to negotiate with the Advisory Council respecting the provision and maintenance of any other institution which may be necessary, especially for the purposes of adaptation and standardisation. Their paramount work would lie in ascertaining from the members of their trades the problems requiring solution and in apportioning these problems to the suitable institutions and the appropriate workers.

There is an extensive field for the national provision of increased facilities for standardisation under the auspices of the Advisory Council for Research, both in the extension of the National Physical Laboratory and, in co-operation with the several trades, in the provision of corresponding facilities in chemistry, including metallurgy, in bacteriology, and, possibly, in other departments of applied science. At first it may be necessary to employ funds provided by Parliament, but if the results of the investigations are adequately protected in the interests of the State the income derived should, in the course of a few years, suffice for all purposes of maintenance.

15. Commercialisation.

Except where factories exist for Government purposes, as in the case of the Royal Dockyards and Arsenals, the final steps in the development of an invention, which I have included in Stage III., will necessarily be carried out in the commercial works. In some cases very little expenditure on experiment will be required at this stage. In other cases entirely new plant will have to be designed and constructed and new factories built. Elsewhere I have suggested that whenever an invention has been developed wholly or partly by means of public money the patent rights should be vested in the State if the State is advised by competent authority to accept the invention. The manufacture should be distributed as widely as possible under payment of a royalty, an adequate share of which should go to the inventor, while the cost of administration and the maintenance of the research laboratories to which I have referred, should be a charge on the remainder. It is from this source that I expect ultimately to meet all the costs incurred by the Research Council. Until this source of income is adequate I think that all the expenses I have recommended would be a very proper charge on the Development Fund. Most inventions will be of the nature of improvements in existing processes and then there will be no difficulty in granting licenses under a State Patent to every member of the trade willing to pay the fixed royalty. Other patents will relate to new processes involving great expenditure in plant and in these cases the issue of licences must be restricted or no one will incur the expenditure in face of unlimited competition. In theory, the Patent Law exists solely to provide for these cases. I am quite aware of many difficulties associated with the proposal for State patents. There will, no doubt, be a tendency for research students, though working with public funds, to sell privately any successful results to manufacturers who are willing to purchase, and this cannot be entirely prevented, but in the majority of cases the superintendents of the laboratory would be acquainted with the progress of the research and no private patent should be held good if it can be shown that it is based on work done in a laboratory wholly or partly maintained by public money. Manufacturers, too, will not be very ready to purchase if they know that the law is against them when the facts come to light. Moreover, in the case of a State Patent previous publication ought not to be a bar. In this I agree with Sir Oliver Lodge. The main discovery is frequently made without any thought on the part of the conductors of the research of its practical application, and is published as a matter of purely scientific interest. When the useful application is made, both the original inventor and the originator of the application to a useful purpose should have a share in the profits.

16. The Industrial Bank.

The invention which leads to the establishment of a new industry raises in an acute form the question of finance. When a body like the Research Council is sufficiently confident of the value of an invention to recommend that it be the subject of a State patent an opportunity appears to be offered to the Industrial Bank, which may be a separate banking company or a branch formed, as recommended by Mr. Olsson, by all the principal bankers for the sole purpose of advancing industrial undertakings. The Technical Advisory Committee, which protects the interest of the Industrial Bank in Germany, would be less necessary when the State has been advised to accept the patent.

17. An Alternative.

A special Committee recently appointed by the Engineers' Club of Manchester has reported that it "is convinced that the British Engineering Industry must organise without delay to take advantage of present opportunities and to meet the conditions which will follow the termination of the war. In our opinion Germany's success has been due to education, to co-operation, and to organisation in manufacturing and selling, backed up by adequate financial support. In Britain, on the other hand, education has been unsystematic, organisation weak, and co-operation between competing firms almost non-existent." Among other matters the Committee recommend the placing of the Consular Service on a more business-like footing, the collection and dissemination of information, advising with respect to the education of engineers and the establishment of new schools and colleges where necessary, as well as scholarships and bursaries, the organisation of research, and the creation of a Ministry of Industry and Commerce with a permanent secretary of great commercial experience and distinction. Work of this kind necessitates in the first instance confidence between the members of the industry. The establishment of this confidence is the principal and the most difficult task in which the scientific and technical press can assist. It is estimated that the capital invested in engineering works is not less than £300,000,000. An annual subscription of one-tenth per cent. on this would provide an income of £300,000 a year. This would provide all the research institutions and all the research workers which could reasonably be required and leave a sufficient margin for the other objects proposed. If the engineering and other trades would organise on this basis they would be independent of the State and the assistance of the Advisory Council would be required only to bring together different associations to deal with matters of common interest. This is an alternative method of solving the problem.

Steps are already being taken by the Chemical Society, the Society of Chemical Industry and the Dyers and Colourists to bring together the chemical trades into a similar association.

18. Summary.

My suggestions may be summarised as follows :—

1. Education in elementary and secondary schools must be more directly associated with *things* so as to develop self-reliance and resourcefulness, not to teach trades.

2. A considerable proportion of teachers should devote a third year of training largely to practical work under conditions enabling them to become acquainted with the practice of some trades.

3. A general knowledge of the phenomena of nature and of processes applied in industry must be more widely diffused by means of popular lectures and otherwise.

4. More completely organised courses of instruction, without breach of continuity, must be provided for industrial workers of all classes, including the leaders of industry, together with the necessary scholarships, fellowships or bursaries to enable the best students to carry on post-graduate research.

5. Existing institutions must be improved and some new institutions must be provided, especially in the chemical trades, to enable scientific discoveries to be developed sufficiently to demonstrate the conditions under which they can be made commercially successful.

6. Some alterations must be made in the patent law to enable the profits arising from investigations conducted wholly or partly at the public expense to be fairly divided between the State, the scientific worker and the manufacturer.

7. Trades should be organised for the purpose of superintending the research work in which they are interested, for the collection and dissemination of information and the distribution of work among firms in the manner in which it can be most effectively and economically carried out in the interest of the industry as a whole.

8. The trade associations should be in close touch with the Advisory Council for Research, and the Council should, where necessary, recommend the award of Parliamentary grants in aid of industrial research carried out under the direction of the associations and make provision for such work in cases in which trade associations are not available, but the

Advisory Council should utilise to the utmost the services of these associations and of professional and scientific societies.

9. As an alternative the Advisory Council for Research should appoint technical committees representative of trades, or groups of trades, to assist it in the organisation of Industrial Research.

10. The National Physical Laboratory should be the central institution for all physical measurements and standardisation, but for chemical processes a separate institution for a trade or group of trades will frequently be required for the work intermediate between the discovery of a new product or reaction in the research laboratory and the adaptation of the process to commercial manufacture.

11. Some method of financing new processes which have been approved by a competent authority, other than the ordinary method of floating a company, is desirable and this may be provided by some form of industrial bank.

19. War Economies.

I cannot conclude this paper without referring to the immense service which the scientific, as well as the popular, press can render to the nation by advocating rational economies in this present crisis. With some reason the public complain that they are urged to economise but are not told wherein economy can be wisely exercised, and they are still obsessed by the principle, which was quite sound during the first few months of the war, of "Business as Usual." Sometimes we are advised not to consume imported food, but we cannot, as a nation, live without a very large proportion of imported foods, and it is clear that if we continue to consume meat at the present rate and demand English meat exclusively, we shall soon lose all our breeding stock and milk supply. To reduce the importation of meat we must reduce our consumption. We want to be told what foods involve the least injury to the nation's credit and make, for their transport, the smallest demands on our Mercantile Marine. We want also more general instruction on food values, especially substitutes for meat. The public must be taught to recognise the treason to themselves and their country involved in the purchase of new clothes for the sake of fashion, and fashion itself should be interned as an alien enemy for the period of the war. In particular those materials, such as leather, of which the supply is largely required for our Army and the Armies of our Allies, should not be purchased except for urgent need. I do not think that economy should be exercised by reducing salaries; this will not necessarily benefit the State except in the case of salaries paid directly from the Exchequer. The only useful economy lies in ceasing to consume unnecessarily the products of labour, while the pecuniary savings thus effected are invested in war loans. This, in effect, is simply a transfer of labour from the service of the individual, to whom it is a superfluous luxury, to the State to which it is in the present crisis a dire necessity.

[A reference to the proceedings at this meeting was made in an Editorial in the ILLUMINATING ENGINEER for March, 1916, p. 76. At the conclusion of Dr. Garnett's paper an introductory address was given by Mr. A. P. M. Fleming, and a discussion then ensued in which Prof. Gregory (*Nature*), Mr. E. Pendred (*The Engineer*), Dr. R. M. Walmsley (Principal of the Northampton Institute), and Mr. W. R. Cooper (*Electrician*) took part. Dr. Garnett and Mr. Fleming briefly replied to the discussion. Finally a resolution expressing the desire of the Circle to be of service in bringing about a fuller appreciation of the value of technical education and industrial research, and in promoting unity of effort in the study of these subjects was proposed by Mr. Gilbert Wood, seconded by Mr. J. S. Dow, and carried unanimously.

The discussion was resumed on May 16th, when an introductory address, summarising recent proposals for the organisation of science, was given by the Chairman (Mr. L. Gaster). In the unavoidable absence of Mr. Hughes, Prime Minister of Australia, an address was given by Mr. Gerald Lightfoot, who is intimately associated with the establishment of a National Institute of Science and Industry in Australia. Among others who took part in the discussion were the Rt. Hon. A. Dyke Acland, Sir John Cockburn, Prof. R. A. Gregory, and Mr. A. J. Mundella, and a further resolution, supplementary to that passed on March 14th, was proposed by Dr. W. Garnett, seconded by Mr. E. J. Benn, and carried unanimously.

We propose to give a full account of these proceedings in our next issue.—ED.]

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL GENERAL MEETING.

(Held at the House of the Royal Society of Arts, London, W., at 5 p.m. on Tuesday, May 9th, 1916.)

THE Annual Meeting of the Society took place as stated above, the chair being taken by Professor Silvanus P. Thompson, D.Sc., F.R.S.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of applicants for membership announced at the last meeting, and these gentlemen were formally declared members of the Society.*

The HON. SECRETARY then presented the Report of the Council for 1915—1916 (see pp. 169).

The CHAIRMAN said that it was matter for congratulation that, in spite of all difficulties, the work of the Society had been uninterrupted, and five meetings of considerable interest had been held. The activities of the Society had received official recognition, and it was also gratifying for the work of a young Society to secure, as it had done, the co-operation of the older and more specialised bodies. The Chairman also alluded to the death of several members of the Society during the war, including two valued Vice-Presidents, Prof. Vivian Lewes and Mr. Edward Allen, both of whom were widely known for their active work in the gas industry.

Mr. F. W. GOODENOUGH (Chairman of Council), in moving the adoption of the Report, said that the remarks of the Chairman on the loss of Mr. Allen and Prof. Vivian Lewes would be widely appreciated. Both might be said to be victims of the war, for Mr. Allen had taxed his strength by extra work on the Explosives Committee of the Ministry of Munitions, and it was while engaged on similar duties that Prof. Lewes caught his fatal cold.

Turning to the Report, Mr. Goodenough said he shared the general satisfaction in the good work done in such difficult circumstances, and it was all the more regrettable that on the financial side the Society, like other institutions, was feeling the strain of the war. It was to be hoped that some of the undertakings which derived benefit from the good work the Society was doing would see their way to assist the Society in this direction.

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* *Illum. Eng.*, April, 1916, p. 117.

The continued usefulness of the Society was due very largely to the zeal which the Hon. Secretary had brought to bear on its proceedings, and the Society owed him a debt of gratitude for his services.

He had pleasure in proposing: "That the Report of the Council for the Session Nov. 1915—May 1916 be formally adopted by the Society."

The resolution was seconded by Mr. O. P. MACFARLANE, and having been put to the meeting was declared carried unanimously.

Mr. L. GASTER (Hon. Secretary) briefly expressed his appreciation of the kind remarks of Mr. Goodenough, adding that the work had been much facilitated by the harmonious goodwill which existed between members of the Council. He had also to acknowledge the able assistance of Mr. Dow, as Hon. Assistant Secretary.

Mr. S. R. MULLARD then proposed:—

"That this meeting extends a cordial vote of thanks to the President, Council and Officers for their efforts on behalf of the Society during the past twelve months."

The resolution was seconded by Mr. J. F. CROWLEY and carried unanimously.

The CHAIRMAN, who incidentally regretted the enforced absence of the PRESIDENT, SIR WILLIAM BENNETT, on Army business, proposed the following resolution:—

"That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms during the past session, and records its appreciation of the encouragement and support which the Society has received."

The Illuminating Engineering Society, he said, was one of the youngest of a long list of societies whose growth and expansion had taken place in that very room. It was necessary to read the record of the scientific work of the Royal Society of Arts during more than a century, prepared by its indefatigable Secretary, Sir Henry Trueman Wood, and published in book form two years ago, in order to appreciate the very useful work the Royal Society of Arts had done.

Mr. F. W. GOODENOUGH seconded the resolution, which was carried unanimously.

The HON. ASSISTANT SECRETARY (Mr. Dow) then read in the abstract the Interim Report of the Committee on Research (see pp. 172).

The CHAIRMAN remarked on the wide range of topics in the Report. There were many matters which obviously required co-operation with other bodies and might only be effectively dealt with after the war. It was, however, desirable to put these suggested researches on record so that they might receive attention at the opportune moment.

Mr. J. F. CROWLEY pointed out that several of the subjects were of vital importance to the textile industry, notably those bearing on the permanence of colours and the production of "artificial daylight." Such matters might well receive the joint attention of the Textile Institute and the Illuminating Engineering Society. When present at the recent Congress of the Institute at Manchester he had suggested the appointment of a Research Committee with similar aims to that formed by the Illuminating Engineering Society, and he hoped that this suggestion would bear good fruit.

Mr. R. C. BUSSEL likewise emphasised the need for co-operation with other bodies in researches on colour. A definition of a standard white surface would be of great scientific benefit.

Mr. Dow referred to the need for agreement on the colour of light utilised in a permanence-test.

On the motion of Mr. GOODENOUGH, seconded by Dr. R. LESSING, the Report on Research was formally adopted and a vote of thanks to the Chairman terminated the proceedings.

REPORT OF THE COUNCIL FOR THE SESSION

(November 1915—May 1916).

Presented at the Annual Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, May 9th.)

THE Report of the Council for the Session 1915—1916 appears in the second year of war, and the circumstances alluded to in the Report for the Session 1914—1915 still continue.

Although during the past year a considerable number of members of the Society have joined the forces, and additions have been made to the number of those engaged largely or exclusively on war work, the activities of the Society have been fully maintained.

MEMBERSHIP.

The membership of the Society is substantially the same as last year—a result which may be considered very satisfactory in the present circumstances.

We have pleasure in recording that the Presidents of the Institutions of Gas and Electrical Engineers, Mr. John Young and Mr. Charles P. Sparks, have kindly consented to act on the Council during the present year.

The Council record with regret the death of two valued Vice-Presidents of the Society, Mr. Edward Allen and Prof. Vivian Lewes.

Among the losses caused by the War we notice two of the younger members of the Society, Mr. G. Maurice, who perished on the *Lusitania*, and Mr. F. Harvey Gooch, who fell in action with the Cameron Highlanders in France.

MEETINGS OF THE SOCIETY.

Five meetings, not including the Annual General Meeting, have been held during the past session.

The opening meeting on November 23rd was devoted to a discussion, initiated by Mr. L. Gaster, on the Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops. The object of this discussion was to make the contents of this important Report well known to members of the Society, many of whom are directly concerned with factory lighting, and to discuss how its recommendations can best be carried into effect by managers of factories and lighting engineers. The Report, which appeared in September, was generally considered to be of great value. It has a special application at the present moment, when so many factories are working overtime on Government contracts, and adequate industrial illumination is particularly important in view of its relation to the output and quality of work as well as the health of workers. The Report has received widespread notice in the technical press, and its recommendations will doubtless have a favourable influence on industrial illumination in this country. The Council desire to express their thanks to Dr. R. T. Glazebrook, the Chairman of the Home Office (Departmental) Committee, for his kindness in presiding over the meeting on this occasion.

The discussion on November 23rd dealt with the general conclusions reached in the Report. At a subsequent meeting on January 11th a further discussion was introduced by Mr. J. S. Dow, who presented photographs and data referring to a considerable number of gas and electric lighting installations. The discussion was useful in showing how, by modern methods, the requirements of the Report could be readily met, and in suggesting a few devices by which the illumination resulting from a scheme of lighting could be determined beforehand.

In view of the rapid progress recently made in connection with electric incandescent lamps and the influence, particularly, of the gas-filled lamps on modern methods of lighting, it was decided to devote a meeting to a discussion on "Recent Developments in the Electric Incandescent Lamp from the Illuminating Engineering Standpoint." This discussion was opened on December 14th, 1915, by Prof. J. T. Morris, who illustrated his address by reference to a number of problems on lighting, in the solution of which special forms of lamps were employed. A feature of this discussion was the exhibition by Mr. S. R. Mullard, for the first time in public, of a new type of "arc incandescent" lamp, the source of light consisting of a ball of tungsten within a hermetically sealed bulb. The thanks of the Society are due to Professor Silvanus P. Thompson for kindly taking the Chair at this meeting.

Recent discussions, particularly that on factory lighting, have served to show the need for greater precision in specifying the amount of illumination required for various purposes. In order to describe the lighting conditions in such cases, it is clearly necessary to have available convenient and sufficiently accurate instruments for measuring illumination. It was therefore considered that the consideration of this subject would be timely, and on February 22nd a discussion on "Some Future Possibilities in the Design of Instruments for Measuring Illumination, with Special Reference to Chemical and Physical Methods," was arranged At this meeting a number of valuable suggestions for the improvement and simplification of illumination photometers were made, and several new types were described and exhibited. Previous to the meeting, a list of queries relating to points on which further information would be desirable was drawn up and circulated among members. By this means some useful information regarding recent advances in the use of selenium and photo-electric cells and other physical methods was received, the contributions from corresponding members in France and the United States proving particularly helpful in this respect.

Since the outbreak of war considerable difficulties have been experienced in obtaining certain varieties of glassware required in the lighting industry, and the fifth meeting of the Society, on March 21st, was devoted to a discussion on this subject. Instances of such difficulties, such as the lack of good heat-resisting glass and the finer varieties of white diffusing glass, were mentioned by Mr. S. B. Langlands in his introductory address on "Some Aspects of the Design and use of Glassware in Relation to Natural and Artificial Illumination," and confirmatory evidence was brought forward by other members of the Society. Various proposals were made with a view to improving present conditions, among them being the encouragement of research and the promotion of greater uniformity of design for articles in common use.

The Society had also the privilege of hearing the views of several members of the Glass Research Committee of the Institute of Chemistry, which has been conducting researches on chemical and optical glassware. From a national standpoint the future development of the glass industry is of considerable importance, and it is proposed to appoint a Committee of the Society to consider the problems involved in the manufacture and supply of glassware for lighting purposes.

OTHER IMPORTANT EVENTS OF THE SESSION.

Reference has already been made to the important Report issued by the Departmental (Home Office) Committee on Lighting in Factories and Workshops, which was issued last September. The Report appeared in the form of three volumes, comprising respectively (1) Report and Appendices; (2) Minutes of Evidence; and (3) Record of Observations in Factories. Amongst other recommendations, the Report proposes that inspectors should be given statutory power to demand in general terms adequate lighting in factories and workshops, and it is to be hoped that this recommendation will be carried into effect as soon as opportunity offers.

The Recommendations of this Report have also been brought to the notice of the Committee now sitting on the Conditions of Health of Munition Workers, and in the bulletins so far issued reference has already been made to the importance of good industrial illumination. Special mention may be made of Bulletin No. 9, on "Ventilation and Lighting of Munition Factories and Workshops," in which attention is directed to the Home Office Report, and the chief essentials of good lighting, as summarised in this Report, are repeated.

It will be the duty of the Society to continue their work on this subject with a view to bringing about wider recognition of the economic and hygienic value of good industrial illumination, and maintaining the interest kindled in these matters. It has been suggested that as a useful basis for further work, the Society might now pass from the general consideration of the subject to the preparation of information on the conditions of lighting applicable to various trades and industrial processes.

The question of factory lighting has also been receiving the attention of the American Illuminating Engineering Society, and at the last Convention, held in Washington in September, 1915, a most useful "Code for the Lighting of Factories, Mills, and other work places," prepared by a Committee of the Society, was presented. This has since been reproduced in THE ILLUMINATING ENGINEER.*

At the Convention a variety of interesting papers were presented, and the Transactions of the American Illuminating Engineering Society throughout the year have contained matter of considerable value.

A series of lectures on various aspects of illuminating engineering is also being arranged, which will doubtless serve to bring up to date the information contained in those given at the Johns Hopkins University (Baltimore, U.S.A.), in 1910. On the occasion of the celebration of the tenth anniversary of the founding of the American Society, an interchange of good wishes between the two Societies took place. The need for close co-operation in dealing with lighting matters is fully appreciated by the Societies on both sides of the Atlantic.

An important question that has been receiving much attention, both in this country and abroad, is the desirability of arriving at a uniform method of expressing the efficiency and illuminating value of gas, electric, and other illuminants. The view is now receiving support that lamps should be rated in terms of the total output of light in all directions. The following resolution has been proposed by the Committee of the American Illuminating Engineering Society on Nomenclature and Standards, and subsequently approved by the Council of that Society, and is recorded in the Report of the Council for the year ending September 20th, 1915* :—

> "(A) That the output of all illuminants be expressed in lumens; (B) that illuminants should be rated upon a lumen basis instead of a candlepower basis; (C) that the specific output of electric lamps should be stated in lumens per watt, and the specific output of illuminants dependent upon combustion should be stated in lumens per B. Th. U. per hour."

During the past year an influential movement for the encouragement and organisation of scientific and industrial research has been developed in this country. At a meeting of technical and scientific societies convened by the Royal Society on March 24th, a resolution was passed, unanimously advocating the formation of a Conjoint Board of Scientific Societies for promoting the co-operation of those interested in pure or applied science.

Attention has also been given to the scheme for the organisation of scientific and industrial research being prepared by the Committee of the Privy Council. The Illuminating Engineering Society will take steps to bring to the notice of this Committee any problems on which research would be beneficial in the interests of the lighting industry.

The Illuminating Engineering Society has intimated its willingness to take part in any movement calculated to bring about unity of effort in these matters, and to co-operate in any investigations bearing on the practical applications of light, in relation to illuminating engineering.

The Council also consider that the moment is opportune to proceed with the work of the Committee on Research, the appointment of which was decided upon in 1914, but was delayed owing to the outbreak of war. This Committee has held several meetings, and has prepared a Report for presentation at the Annual

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*Vol. VIII. 1915, pp. 414, 441, 451; vol. IX. 1916, p. 135.

* Trans. Ill. Eng. Society (U.S.A.), No. 1, Vol. XI., February 10th, 1916.

Meeting, summarising various subjects for investigation which might receive the attention of the Society. The list of subjects has been made as complete as possible in order to show the variety of problems which require investigation. The Committee will consider which subjects should receive immediate attention, and will take the necessary steps to secure the co-operation and enlist the support of other bodies when dealing with problems of national importance.

ADDITIONAL SUPPORT NEEDED.

The Council are glad to be able to again record the gratifying fact of the Society being able to continue its labours, in spite of the unprecedented circumstances arising through the war.

The Society is fortunate in benefitting by the arrangement providing for THE ILLUMINATING ENGINEER to act as the official organ, and to undertake the publication of translations, the cost of which would otherwise be prohibitive, and has not been called upon to pay many customary expenses, such as rent of offices, secretary's salary, &c. Nevertheless the experience of the past year has served to emphasise the desirability of securing additional funds in order to enable the work of the Society to be carried on in a satisfactory manner. During the present circumstances the Council are unwilling to recommend any radical departure in this respect, but it is evident in the near future the Society must either secure a considerably enlarged membership, or increase its present moderate subscription to £2 2s., as was originally provided at the time of the foundation of the Society, or secure substantial support from such institutions as directly benefit from the movement.

The attention of members is also drawn to Article 23 in the Constitution of the Society where it is laid down that "any member may commute or compound for all future payments and become a member for life, by payment of a sum of not less than £10 10s. 0d. (ten guineas)." It is hoped that a number of members will take advantage of this method in order to provide additional funds.

PROGRAMME FOR THE NEXT SESSION.

The Council is now engaged in preparing the programme for the next session. Members who are willing to read papers are invited to notify the Hon. Secretary as soon as possible and to send in contributions during the vacation. The list of subjects for investigation at the end of the Report on Research may suggest some suitable subjects for papers.

SIR WILLIAM H. BENNETT,
President.

F. W. GOODENOUGH,
Chairman of Council.

LEON GASTER,
Hon. Secretary

INTERIM REPORT OF THE COMMITTEE ON RESEARCH.

(Presented at the Annual Meeting of the Society held at 5 p.m. on May 9th at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.)

THE appointment of this Committee was announced at the end of the Session in 1914, but owing to the disturbance caused by the war it was not found practicable at that time for the Committee to take up the tasks before it. The present moment, when so much attention is being devoted to the promotion of scientific and industrial research, appears favourable for the resumption of the work. An important step has been the appointment of a Committee of the Privy Council in order to study the organisation of Scientific and Industrial Research, and the Royal Society and other bodies are considering the best means of promoting unity of effort between the various scientific and technical societies of the country.

The following gentlemen have at

present been nominated to serve on the Research Committee of the Illuminating Engineering Society:—Mr. A. Blok, Mr. J. G. Clark, Mr. W. C. Clinton, Mr. J. F. Crowley, Mr. F. W. Goodenough, Lieut. Haydn T. Harrison, R.N., Dr. James Kerr, Professor T. Mather, Professor J. T. Morris, Mr. S. R. Mullard, Mr. C. C. Paterson, Professor Silvanus P. Thompson (Chairman), Mr. A. P. Trotter, Mr. F. W. Willcox; *ex officio* Mr. L. Gaster (Hon. Secretary) and Mr. J. S. Dow (Asst. Hon. Secretary).

The immediate object of the Committee was to prepare a list of subjects specially deserving of research at the hands of the Society, and the suggestions so far received, together with others arising out of past discussions of the Society, have been assembled in the list at the end of this Report. The Committee will welcome any additional suggestions, or intimations from members of any experiments which are already in progress. It is hoped that this list will also be useful in suggesting subjects for future discussions at meetings of the Society.

While not intended to be exhaustive the list already contains many more subjects for investigation than could be at present undertaken by the Society. It will, however, serve to show how past discussions have developed prospects of further useful work, and the many opportunities for research now before us.

In dealing with these suggestions the Committee may nominate from among its members sub-committees to organise or undertake specific researches or may take advantage of the services of other members of the Society or gentlemen outside the Society who have special knowledge of the proposed researches. Some of the investigations in contemplation will involve co-operation with other Societies and Institutions. The Society has been in touch with the various Associations and Committees for the organisation of scientific research, and it will be the function of the Committee to invite their co-operation on subjects of common interest and enlist their support in dealing with problems of national importance. The Committee will consider which subjects deserve prior attention, both with a view to their urgency and the prospects of obtaining the necessary support and securing favourable results in the near future.

There are on the list many subjects of great scientific importance which would involve long continued experiment and co-operation with other bodies, on such a scale as cannot reasonably be expected while the war continues; these matters will therefore have to be postponed for consideration at a later date.

In regard to matters connected with the war it is naturally impracticable to discuss in public all opportunities for service that may occur. Many members of the Society are already engaged upon work of this nature and any suggestions that they may bring to the notice of the Committee will naturally receive prior attention.

In connection with subjects of importance from the industrial standpoint the Committee suggest that priority should be given to investigations relating to the development of lamps and lighting appliances, and researches having for their object the elucidation of general problems on which the development of the lighting industry depends. As an instance, the investigation of the properties of illuminating glassware is a matter which, in the opinion of the Committee, should receive immediate attention at the hands of a special sub-committee appointed for the purpose.

Another subject which merits early attention in view of its relation to the dyeing and colouring industries is the preparation of a standard series of colours and in particular of a standard white surface, suitable for acceptance in all researches in which the accurate definition of colour is involved. Conjointly with this subject the design of suitable apparatus for analysing and specifying colour and for measuring the reflecting power of various materials should receive attention. There is also the further problem of providing a fixed standard for the permanence of coloured materials.

In dealing with this and the preceding matter the co-operation of other associations interested would be desirable.

In view of the growing recognition of the need for precise quantitative specifications of illumination required in practice for different purposes, the preparation of a standard specification for illumination photometers, to be used in determining the performance of legal contracts involving the measurement of illumination, might be studied with advantage. The general question of the simplification of illumination photometers, and particularly the problem of producing a direct-reading instrument based on physical or chemical effects, which was discussed at a recent meeting of the Society on February 21st should also be borne in mind.

Among other matters which, in view of their important bearing on the future development of lighting, deserve special attention, may be mentioned :—the study of glare and the limits of permissible intrinsic brilliancy; the investigation of the comparative effect on vision and the physiological influence in inducing fatigue of natural and artificial illumination and of various systems of artificial lighting; and the conditions, as regards the intensity of illumination and arrangement of lights, desirable for various industrial operations. The latter question is of interest as being supplementary to the Report of the Home Office Departmental Committee on Lighting in Factories and Workshops, and it is suggested that the preparation of an illustrated Bulletin forming a guide to the best present practice in various sections of industrial lighting, might be undertaken.

In the list of researches the various suggestions have been roughly classified under the following headings :—

(*a*) Photometry, Standards of Light, and Researches on Colour.

(*b*) Electric, Gas and other Illuminants.

(*c*) Lighting Appliances.

(*d*) General.

(a) Photometry, Standards of Light, and Researches on Colour.

(1) *The Production of a Satisfactory Standard of Light.* It would be of interest to collect information furnishing a summary of the present position, preliminary to further researches, which would probably require action under the joint auspices of the National Physical Laboratory and the National Illumination Commission. This is essentially an international matter and only preparatory work could be done while the war continues.

(2) The development of a *Standard Laboratory Photometric Equipment* to take the place of those designed abroad. This again demands the co-operation of the National Physical Laboratory. In this connection the establishment of the suggested Central Optical Institute, where suitable photometric instruments with the necessary optical appliances could be developed, would be of considerable value.

(3) The specification of a *Series of Standard Colours* and of methods of determining the amount of light reflected from them and the general problem of a method of determining the total reflection from all kinds of surfaces, should be considered.

(4) The standardisation of *methods of analysing and specifying colour*, and design of simpler and more convenient instruments for testing the same. This is a matter of considerable scientific importance for the future development of the dyeing and colouring trades.

(5) The standardisation of the so-called "*Artificial Daylight*" (*i.e.*, the various forms of artificial light used in conjunction with special devices in order to imitate the colour of Natural Light). In investigating this question an attempt should be made to arrange the chief artificial illuminants in the order of their resemblance to daylight. This question has often been discussed but never authoritatively settled. At present there also appears to be no universally accepted *standard of* "*white light*" nor any generally accepted "*standard white surface.*"

(6) A closely related problem is the effect of different qualities of light on *the permanence of colours.* There does not appear to be any recognised and generally accepted method of testing the "fastness" of dyes, although various artificial illuminants have been proposed for use in this respect.

[(3), (4), (5) and (6) would require the co-operation of representatives of the chief industries concerned with coloured goods and coloured matching.]

(7) The subject of *colour-photometry*, on which much experimental work has been done, requires clearing up, but it is a vast problem, falling within the scope of the National Illumination Commission

and the National Physical Laboratory, and its full consideration would ultimately involve international co-operation.

(8) The question of *direct-reading physical photometers* was discussed at a recent meeting of the Society, and a number of fruitful investigations were suggested.

(9) The design of better and simpler *illumination photometers.* Instruments of the simpler class are probably best left to individual workers; but it would be useful to make an inquiry into the probable accuracy of the various kinds available, and to institute a series of comparative tests with various instruments by different observers in streets and interiors. The preparation of a *specification for illumination photometers* intended for tests in which contracts and legal penalties are involved might follow after the above experiments.

(b) Electric, Gas, and other Illuminants

(10) Experiments on *the improvement of lamps* are naturally undertaken mainly by manufacturers, but questions of scientific interest arise, the elucidation of which would be of value in establishing the principles governing the efficiency of illuminants. In many such cases the immediate commercial return may not be sufficient to induce individual manufacturers to make experiments, but there is scope for the prosecution of such inquiries in the laboratories of technical and scientific institutions, and the Society would gladly welcome cooperation on the part of the manufacturers and suggestions regarding experiments of this nature.

The time is ripe for promoting greater uniformity in methods of *testing and describing the illuminating value of lamps of various kinds*, and it would be advantageous if general agreement on this point could be obtained.

(c) Lighting Appliances (Globes, Shades, Reflectors, &c.).

The remarks made under the last heading also apply here.

The supply of *optical glass* and the investigation of its properties are at present of great national importance and the Committee would be glad to receive any suggestions for useful service in this direction.

As regards *glassware required in the lighting industry*, it is common knowledge that considerable inconvenience has been caused by the shortage of many kinds of glass hitherto imported and there appear to be opportunities for research in connection with the manufacture of these varieties of glass in this country.

It is accordingly suggested that a sub-committee should be appointed to consider—

(11) The best means of promoting the scientific study of *lighting glassware* and of encouraging the manufacture of kinds of glass which have not hitherto been developed satisfactorily in the British Isles. Amongst such varieties may be mentioned suitable heat-resisting glass for use in chimneys, globes, &c., used with high temperature illuminants; white diffusing glassware having suitable qualities as regards minimum absorption of light, uniformity of structure and diffusion of light; neutral tinted glass of specified absorbing value required for optical and photometric work; and special varieties of coloured glassware used for the production of "artificial daylight."

(12) Appropriate methods of *testing and prescribing the requisite qualities of glassware* of the above kinds.

(13) *Uniformity of method in testing and specifying the distribution of light, absorption* and other qualities of globes and reflectors of importance from the illuminating engineering standpoint.

(14) The best means of promoting agreement as to *uniform sizes and shapes of glass articles in common use in the lighting industry*, in cases where such uniformity is desirable in the interests of manufacturers and the public.

In connection with these researches the co-operation of other bodies interested in the study of glassware would no doubt be desirable.

(d) General.

Among other suggestions may be noted:—

(15) Research work on an instrument for the *automatic control of artificial light in factories, schools, &c.*, the light being automatically turned on when the

illumination has fallen to a certain value. This is a problem more hopeful of immediate solution than the design of a direct reading physical photometer, and there are already several suggested forms of apparatus which deserve comparison and study.

(16) As a development of the Home Office Report on Factory Lighting it would be helpful to make further unofficial investigations on the *conditions desirable for various classes of work*, and subsequently to issue these as a brief series of recommendations for the guidance of managers and others interested in factory lighting.

(17) A good deal remains to be done in further prosecution of the work of the *Daylight Illumination in Schools.* The Joint Committee appointed by the Society in 1913 reported shortly before the outbreak of war and made a number of suggestions for future work.* At that time there appeared no immediate prospect of securing the assistance requisite to carry these investigations to completion, but it is hoped to proceed with them when opportunity offers.

(18) *Street lighting*, after the war, will be a good field for effort, particularly as regards the development of more decorative forms of design as well as more scientific treatment in respect of the shading of lamps and the distribution of light. The war has impressed people with the importance of street lighting, and the conception of a minimum illumination desirable in the interests of safety should be encouraged.

As regards the design of lanterns placed outside public buildings work might be done in co-operation with Arts and Crafts Associations and the London Society. It might at least be possible to form clearer ideas during the war as to what could be accomplished afterwards.

(19) *Searchlights.* There are many questions of interest, but their full consideration at the present time would require the co-operation of the military and naval authorities. At the meeting in February, 1915, it was suggested that experiments might be made on the following points :—

Possible improvements in efficiency (as for example those involved in the new searchlight evolved by O. Lummer of Breslau).

Investigations into the various points suggested by Mrs. Ayrton in connection with the choice of carbons, best electrical conditions, &c. ; also into the type of electrical generator best adapted for searchlights.

Preparation of simple instructions for working searchlights.

Attempt to define more precisely the "range" and the "candlepower" with a view to these quantities being specified in the future.

Inquiry into the best colour of light, as regards its effect on penetrating power and on the apparent sharpness of object illuminated by the searchlight beam.

(20) *Visibility.* A series of queries was put forward in connection with the paper on this subject by Messrs. Paterson and Dudding (*Illum. Eng.*, May, 1915, p. 208). Many of these, such as the relative visibility by natural and artificial light, by direct and indirect light, &c., require study.

The question is of military interest in connection with concealing operations from the enemy, rendering uniforms, aeroplanes and ships difficult to see, and possibly in the future some investigation would be considered by the War Office or Admiralty.

(21) *Lighting of Rifle Ranges.* The series of queries prepared in this connection has not been completely answered.* It was proposed to form a Committee to deal with the matter, but so far it has been difficult to find members who were free to undertake such experiments.

(22) An inquiry is suggested into the *Physiological difference between Natural and Artificial Light, e.g.*, the intensities considered necessary for vision.

(23) Investigation of the conditions determining *permissible limits of intrinsic brilliancy* ("Glare"). A suggestive Report on this subject has been issued by a Committee in the United States, which merits discussion.

(24) The problem of devising some means of judging *the comparative effect on the eyes of various methods of lighting, as regards fatigue, comfort of vision, &c.*

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* *Illum. Eng.* July, 1914, p. 365.

* *Illum. Eng.*, June, 1915, p. 250.

An attempt in this direction has been made in the States, but little has been done in this country.

(25) *Library Lighting.* Various points remain for consideration from the discussion and subsequent report of the Committee in 1911. The lighting of racks and shelves is still regarded as a somewhat difficult problem.

(26) *Lighting of Museums and Picture Galleries.* It was proposed to form a Committee to study this subject previous to the war, after the discussion initiated by Professor Thompson in 1914. Among the points for consideration are the general arrangements of natural and artificial lighting to illuminate pictures and exhibited objects in showcases; the possibility of employing a method of illumination resembling daylight in colour; the desirability of special local lighting for certain pictures, objects in showcases, &c.

(27) *Lighting of Hospitals.* The lighting of hospital wards is admittedly often unsatisfactory. There is also room for investigation in the lighting of operating tables. The subject might also be studied in connection with field hospitals using portable illuminants, &c.

(28) *Testing the gloss of paper,* and the determination of a *standard of matness.* This matter has been carried to a certain stage by Mr. Trotter's experiments and the inquiry of the Committee of the British Association (*Illum. Eng.*, October, 1915, p. 425), but the subject still requires investigation.

(29) *Nomenclature of illuminating engineering.* The subject was left in a state of suspension before the war, and requires international treatment.

(30) Tests of the effect of varying *the reflecting power of walls, ceilings and floors in rooms,* with a view to preparing data by the aid of which the increased illumination due to reflected light may be more precisely estimated. The effect of varying these conditions on the shadows and diffusion of light also deserves inquiry.

TENTH ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY, U.S.A.

THE Tenth Annual Convention of the American Illuminating Engineering Society will be held in Philadelphia, September 18th, 19th, and 20th, 1916.

Immediately following the Convention there will be given at the University of Pennsylvania under the joint auspices of the University and the Society, a course of twenty lectures on the theoretical and practical aspects of Illuminating Engineering.

The lectures will be delivered by eminent authorities in the lighting world, and will occupy approximately eight days.

Further particulars of this course of lectures will be issued later.

TENTH ANNUAL MEETING OF THE BRITISH SCIENCE GUILD.

THE Tenth Annual Meeting of the British Science Guild took place in the rooms of the Royal Society of Medicine (Wimpole Street, London) at 4 p.m. on Wednesday, May 17th, the chair being taken by the President, the Rt. Hon. Sir William Mather.

The usual Annual Report was presented. It contains a very serviceable summary of the chief events in the scientific world during the past year, reference being made to the work of the Advisory Council to the Committee of the Privy Council on Scientific and Industrial Research, the proposal of the Royal Society to form a Conjoint Board of Scientific Societies, and other important matters. A feature is the Appendix, by Prof. R. A. Gregory, on "The Promotion of Scientific Research and Higher Education."

In the course of the meeting an address was given by the Rt. Hon. Andrew Fisher, who explained the proposed establishment of a National Institute of Science and Industry in Australia. Among others who spoke, Dr. R. Mullineux Walmsley referred to the need for a National School of Technical Optics, and Sir Alfred Keogh gave a brief account of the application of science in the work of the R.A.M.S., instancing the marvellous success attained in the prevention of typhoid fever.

REVIEW OF BOOK.

Newsholme's "School Hygiene; the Laws of Health in relation to School Life," by James Kerr, M.A., M.D. (*Geo. Allen and Unwin, Ltd., London.* 1916. *pp.* 352; *illustrations,* 49.)

NEWSHOLME'S "School Hygiene" was first published in 1887, and attained its twelfth edition in 1907. The book has now been re-written and brought up to date by Dr. James Kerr, whose name will be familiar to readers as one who has taken a deep interest in the scientific lighting of schools, and who participated in the work of the Joint Committee of the Illuminating Engineering Society dealing with this subject.

The early portion of the book is devoted to physiology, psychology, and ethics in relation to hygiene. The nature of the organs of speech, sight, and hearing, and the centres of perception are explained, and the author then passes on to show the bearing of this information on school life. Some questions of wide general interest are discussed: for example, the value of open-air schools in combatting consumption; the care of abnormal and physically defective children; nutrition, physical education and medical inspection. A specially interesting chapter deals with mental and physical fatigue. Apparently there are now quite a variety of methods of testing fatigue, some of which have already proved of value in the study of industrial hygiene. There are also practical suggestions on clothing and cleanliness and the organisation of first aid in case of accidents. Some diagrams are presented showing the tendency towards deterioration of vision during school life, and the author refers to several defects in lighting which are apt to accentuate these conditions. Special importance is attached to the use of good white paper in school books, and type of suitable size.

Part II., dealing with apparatus, contains several chapters on ventilation and heating, of which the author has made a special study. After considering the selection of a suitable site for a school, we come to the design of the class-room, where heating, lighting, and ventilation must often be considered conjointly. The selection of suitable school furniture also merits attention. We are glad to see that a special chapter has been devoted to illumination—a matter which has sometimes been overlooked in works on school hygiene. Dr. Kerr discusses the fundamental principles of good lighting, such as the proper position and area of windows, the direction of artificial light and the avoidance of glare, in connection with which he quotes from the recommendations of the Joint Committee of the Illuminating Engineering Society.

The ideas of the author are expressed in simple language and the pages are illustrated by many useful diagrams. Apart from its evident value to school medical officers and educational authorities, the book will be read with interest by many who have little technical knowledge of the subject treated.

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Illuminating Engineering Society—

(Founded in London, 1909)

Annual General Meeting (PROF. SILVANUS P. THOMPSON—MR. F. W. GOODENOUGH—MR. O. P. MACFARLANE—MR. L. GASTER—MR. S. R. MULLARD—MR. J. F. CROWLEY—MR. R. C. BUSSELL 167
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THE LATE SIR CORBET WOODALL.

READERS of the Journal will have learnt with a lively regret, shared by all who ever came in contact with him, of the death of Sir Corbet Woodall, J.P., D.Sc., M.Inst.C.E., Governor of the Gas Light and Coke Company and the leading consultant in the world of gas engineering, which took place rather suddenly on May 17th at Torquay, whither his doctors had ordered him for a short spell of rest and recuperation. For some time past his health had not been satisfactory, owing largely to the fact that his mental energy, like his appearance, belied his 75 years, and tempted him to work himself to a degree of which his bodily powers could no longer stand the strain.

One could almost wish him to have fallen where he stood in the works or offices of the Gas Light and Coke Company, for if ever anyone lived, moved, and had his being in the work of his choice, Sir Corbet was that man ; and his employees knew him to be not in name alone but in very truth the Governor of that great Company with which he was so intimately associated. They will long remember him as an engineer who "knew his job" down to the smallest detail ; as a master who demanded the best of which those who served him were capable, but was equally unsparing of himself ; as a man no less ready with encouragement and sympathy where such were needed than with criticism and reproof where such were deserved.

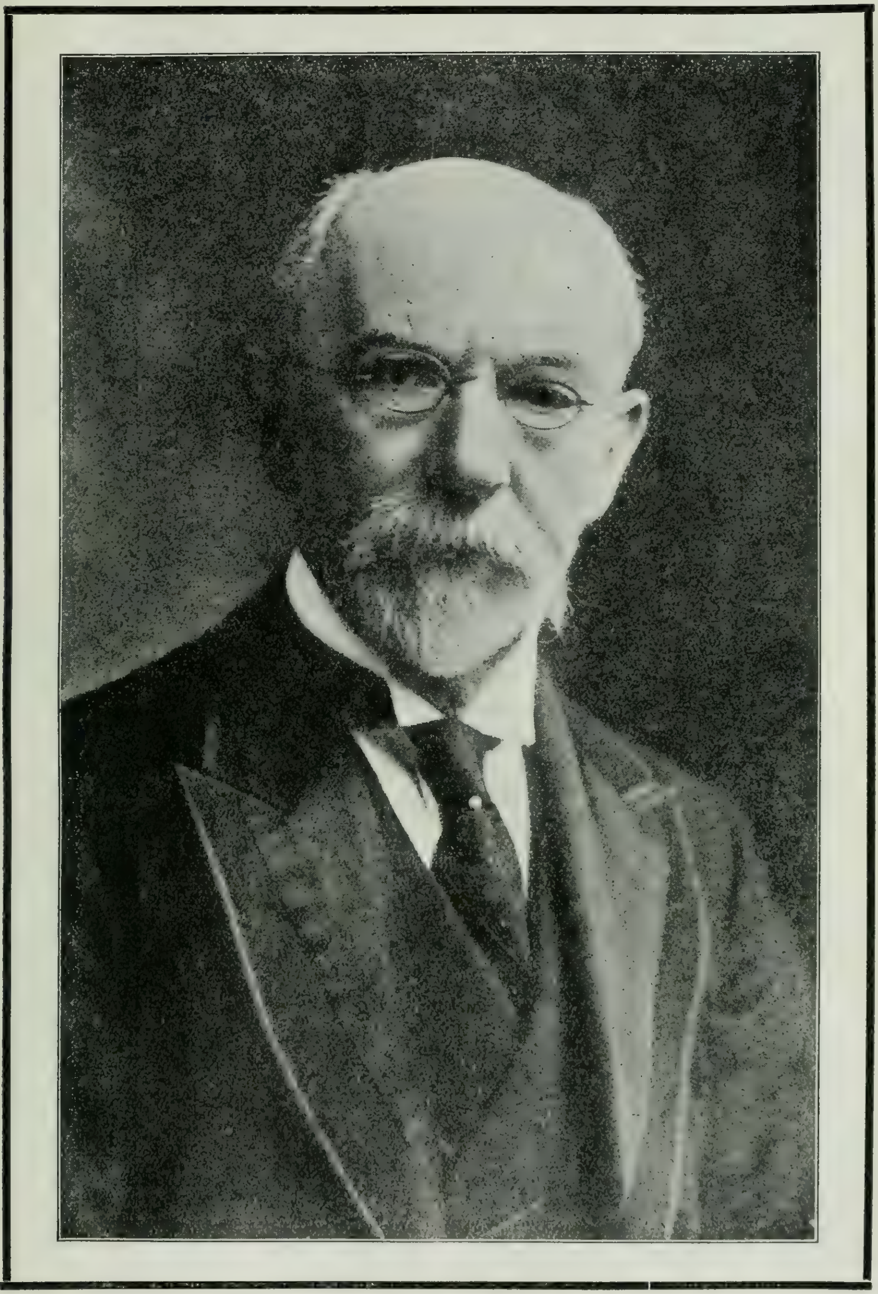
Sir Corbet Woodall became Governor of the Gas Light and Coke Company in the year 1906, and for several years previously had been the moving spirit on the Board. One of the earliest services he rendered to the Company was to initiate the establishment of good relations between it and its consumers by the organisation of a sales department founded on the principle of mutual benefit ; and it was not long before the soundness of this policy was amply vindicated. His genius for administration found further scope in the well-known "co-partnership" and "apprenticeship" schemes of the Company, in both of which undertakings he was a prime mover. Under the former of these schemes substantial bonuses reward faithful service, without prejudice to rates of pay and hours of labour ; by the latter, boys who have just left school undergo six years' free training in gas fitting in the Company's workshops together with a specially-arranged continuation course at the L.C.C. Westminster Technical Institute. The success of this arrangement was an abiding joy to Sir Corbet, whose sympathy and support could always be enlisted for educational clubs for boys and other such undertakings.

Of the world-wide engineering reputation of "the veteran head of the gas industry," as he has been termed with admiring affection, there is little need to speak here. Suffice it to recall that he was knighted by King George on January 1st, 1913, immediately following the year of the centenary of gas lighting (1912), when he held simultaneously the three offices of President of the Institution of Gas Engineers, President of the Society of British Gas Industries, and President of the British Commercial Gas Association, as well as that of President of the National Congress and Exhibition in which all three organisations joined. In that same year, moreover, his research and other scientific work won him the honorary degree of Doctor of Science of Leeds University. For our own Society, of which he was an honorary member, he had warm sympathy, though the pressure of his many other engagements and the strict orders of his doctor rendered it impossible for him to be a frequent visitor at our meetings.

Chief, perhaps, of all the many ways in which he served his country after the outbreak of war was the part he played in bringing about the successful development of engineering methods which enabled the gas undertakings of the Kingdom to meet the demands made on them by the Ministry of Munitions for an adequate supply of materials for high explosives. His death is a real loss to the country, as well as to the whole engineering world, and in particular the gas industry : for

"He was a man : take him for all in all,
We shall not look upon his like again."

F. W. GOODENOUGH.



By the courtesy of the "Journal of Gaslighting."

SIR CORBET WOODALL,

GOVERNOR OF THE GAS LIGHT AND COKE COMPANY.

BORN AUGUST 27, 1841. DIED MAY 17, 1916.

SCIENCE IN EDUCATION AND EXAMINATIONS.

A meeting called by the Committee on Neglect of Science, took place at Burlington House on May 3rd.

Lord Rayleigh, who presided, remarked that the ignorance of natural science among all classes was deplorable, and urged that in educational institutions more attention should be given to this subject, and also to modern languages. Sir Ray Lankester spoke to the same effect, and the following resolution was then moved by Sir E. Schäfer, and supported by Dr. Bridges, Lord Montagu, Col. Crompton, Lord Portsmouth, Mr. H. G. Wells, and other speakers :—

> "That in the opinion of this meeting it is a matter of urgency, in order to promote national efficiency in the near future, that the natural sciences should be made an integral part of the educational course in all the great schools of this country, and should form part of the entrance examination of the universities of Oxford and Cambridge, as well as of the newer universities."

Another resolution was moved by Sir H. Johnston :—

> "That it is in the highest degree desirable that the Government should exercise the large power it possesses of encouraging the study of the natural sciences, and thereby increasing the efficiency of our public servants : (1) by assigning capital importance to the natural sciences in the competitive examinations for the Home, Indian, Foreign, and Colonial Civil Service ; 2) by requiring some knowledge of the natural sciences from all candidates for admission to Sandhurst."

This resolution received the support of Prof. Poulton, Prof. Turner, and Mr. Nowell Smith of Sherborne, and was likewise adopted.

ORGANISED SCIENCE.

A conference, at which many of the chief technical and scientific societies were represented, was called by the President and Council of the Royal Society on March 22nd, when the following resolution was passed unanimously :—

> "This meeting considers that it is desirable to establish a Conjoint Board of Scientific Societies for the purpose of :—
>
> "(1) Promoting the co-operation of those interested in pure or applied science ;
>
> "(2) Supplying a means by which the scientific opinion of the country may, on matters relating to science, industry and education, find effective expression ;
>
> "(3) Taking such action as may be necessary to promote the application of science to our industries and to the service of the nation ;
>
> "(4) Discussing scientific questions in which international co-operation seems advisable."

A Committee has been appointed to consider the best means of giving effect to this resolution.

ECONOMY IN LIGHTING.

A circular issued by the Board of Trade draws attention to the need for economy in the use of fuel at the present time, in order to enable the export trade to our Allies and neutrals to be maintained.

With a view to promoting economies in this direction, the Central Coal and Coke Supplies Committee have recommended that a general policy of economy in lighting should be adopted. Gas and Electric Lighting undertakings are accordingly asked to notify to consumers the Government's desire that the consumption of coal for lighting purposes should be reduced by 10 per cent.

(We propose to deal more fully with this matter in our next number.—Ed.)

ELECTRICITY · ACETYLENE

The

ILLUMINATING
ENGINEER

OIL · GAS

Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
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EDITORIAL.

The Technical Press and Economy in Lighting.

We have recently had occasion to mention the important public services to be rendered by the scientific and technical press in disseminating knowledge of scientific value and stimulating interest in industrial research. In the present issue we complete the discussion on this important subject, which took place at recent meetings of the Circle of Scientific, Technical, and Trade Journalists on March 14th, and again on May 16th.

We believe that there is a great field for co-operation between the Press, the chief scientific institutions and the State in bringing new ideas before the public, and guiding opinion in the right direction.

A good opportunity for the exercise of such educational effort is afforded by the urgent need for judicious economy in the use of fuel, emphasised in a recent circular from the Board of Trade, to which we referred in our last issue (p. 182). We also appreciate the urgency of the problem. But it is now fully recognised that proper illumination is an absolute necessity in daily life. The adequate lighting of an office or factory is as essential to the carrying on of work as the tools and materials employed. In support of this view we need only quote from the recently issued Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops, wherein it is acknowledged that defective lighting leads to spoiled work and diminution of output, and is a contributory cause of accidents and ill-health. This view has also received the support in the

Bulletin on the Lighting and Ventilation of Factories, issued by the Committee of the Ministry of Munitions on the Health of Munition Workers. In our streets and in our homes adequate illumination is likewise necessary in the interests of health.

It appears to us, therefore, that in striving for economies in lighting we should aim, not at an indiscriminate reduction, which might defeat its own purpose by causing drawbacks which outweigh the actual economy in fuel, but at *the exercise of greater care in the use of light.* Light which does not fulfil its object—which dazzles the eyes of workers instead of illuminating the material on which they are engaged—is undeniably wasted, and this waste should be checked. In our experience substantial economies have often been made by introducing the most efficient forms of lamps, and adopting scientifically designed reflectors which direct the light where it is needed. Glassware for this purpose is made in Enlgand in large quantities, and its use should also be extended on the national ground of encouraging home industries. It is the duty of the illuminating engineer to promote economies by these methods ; and if Government Departments can bring their influence to bear in inducing people to adopt more scientific methods of lighting, they would not only achieve a much-needed present economy, but do valuable work for the future.

Apart from the opportunities for such economy in the interior lighting of buildings, we see around us many instances of waste of light, even in our dimly-lighted streets. For example, we see powerful street lamps, consuming a considerable current, but obscured so heavily that only a fraction of their light escapes into the street. In several districts we understand that considerable economies have been made by substituting for arc lamps suitable incandescent lamps of much smaller consumption in appropriate reflectors. Again, in many shops we see numbers of lamps, the light from which has been almost completely blocked by shrouding them with coloured paper or by covering the bulbs with obscuring lacquer. Fewer lamps of smaller consumption, equipped with properly designed screens, would serve the purpose much better.

These are a few instances of the waste of artificial light, and it may be recalled that a fuller use of daylight may also lead to economies. In the case of buildings with unduly small window area, or obstructed by neighbouring obstacles, the untimely diminution of daylight leads to artificial light being employed at a needlessly early period. In many such cases by making use of mirrors, or panes of suitable diffusing glass, the period during which daylight can be used may be lengthened, and the time during which artificial light is necessary restricted.

To put the matter in a nutshell, we venture to suggest that in further circulars the Board of Trade might well lay stress on the forms of economy mentioned above, inviting the co-operation of the technical press in order to bring about the needed saving in fuel. Many different aspects of the subject will occur in connection with various trades and technical journalists who are conversant with such industries, could doubtless often make suggestions in their columns which would tend in the desired direction. We feel sure that the importance of the matter would be readily appreciated if conveyed in this form ; and members of the Illuminating Engineering Society, who have from the very first aimed at the suppression of waste of light on general grounds, would doubtless be only too glad to co-operate in such a campaign.

Photo. Lafayette.

Professor Silvanus P. Thompson.

BORN, JUNE 19th, 1851. DIED, JUNE 12th, 1916.

It is with deep sorrow that we record the loss of Professor Silvanus P. Thompson, First President of the Illuminating Engineering Society, who passed away after a brief illness on Monday, June 12th.

His unexpected death came as a painful shock to the world of science not only on account of its suddenness, but because of the many close personal associations to which his singularly lovable and kindly disposition and his versatile gifts gave rise. Up to the very last he pursued his usual active interest in scientific work. On the Friday before his death he attended

Dr. Clarke's lecture on eyesight before the Royal Institution. Only a few weeks ago, in presiding at the Annual Meeting of the Illuminating Engineering Society, he spoke with all his accustomed charm and idealism, encouraging us by pointing out how many of the aims and objects of the Society—so admirably expressed in his own Inaugural Address in 1909—were gradually being carried into effect. We cannot do better than quote from what we now feel to have been a farewell message :—

> " The whole function of the Society is to produce good lighting by whatever means, and the fact that Departmental Committees and officials of the Home Office are now persuaded, and more than persuaded, that this is a step to be fostered governmentally, is a complete justification for the existence of the Society. This, however, does not justify us in folding our arms and saying that our work is done, but it is an encouragement to go on in the future in the same direction and improve lighting of all kinds for the benefit of the community."

In Professor Thompson there were united rare intellectual gifts that gained for him a European reputation, and personal qualities that won the esteem and love of all with whom he came in contact. Throughout his active career he was almost equally eminent in engineering work and in pure science.

Optical problems had a special fascination for him, and his lectures before the Royal Institution on " Light, Visible and Visible," were afterwards collected in a book that became very widely known. He filled the Presidential Chair of the Institution of Electrical Engineers, and the Physical, Optical, Röntgen and Illuminating Engineering Societies. In many cases he was among the first to give his support and encouragement to new institutions. The Illuminating Engineering Society, at least, owes him a debt of gratitude which can never be repaid.

With his wide, technical, and scientific knowledge he combined remarkable literary powers, a taste for antiquarian research, and practical ability as an artist and a musician. As an expositor of scientific subjects he was unrivalled. His books are models of lucid explanation, and he had, in a very marked degree, the power of interesting students and inspiring them with his own enthusiasm. His quick mind, tact, and *savoir faire* made him an ideal Chairman. His deep knowledge was adorned by a graceful gaiety and lightness of touch that gained the hearts of his audience.

These same qualities stood him in good stead at international gatherings, where he formed many close friendships. He spoke several European languages fluently. The writer has a vivid recollection of his graceful, address in Italian, delivered at a dinner given to Professor Pacinnotti, on the occasion of the International Electrical Congress, held in Turin in 1911.

In the Illuminating Engineering Society he endeared himself by his conscientious execution of his duties as President, and the admirable way in which he smoothed away conflicting interests—always cheerful and optimistic, with a generous recognition of the services of others, and a kind thought for all with whom he came in contact. He seemed by instinct to know the right thing to do and say on each occasion, and it was in no small measure, owing to his influence in the early stages, that the Council Meetings of the Society have, from the very beginning, been carried on in such an amicable and friendly manner. In his personal dealings with Professor Thompson the writer cannot recollect ever hearing him say a harsh word of any one. If he could not praise he would not blame. Truly he was a man such as one meets but seldom ; and his loss, difficult as yet to realise, leaves a gap in the ranks of science which it will be hard indeed to fill.

LEON GASTER.

THE SPHERE OF THE SCIENTIFIC AND TECHNICAL PRESS IN RELATION TO TECHNICAL EDUCATION AND RESEARCH.

By A. P. M. Fleming.

(Introduction to a discussion at a meeting of the Circle of Scientific, Technical and Trade Journalists held at the Hall of the Institute of Journalists, Tudor Street, Blackfriars, London, at 8 p.m., on Tuesday, March 14th, 1916.)

(*Continued from p.* 166, *May* 1916, *Vol. IX.*)

General.

The fundamental requirement in manufacturing is to produce marketable commodities in the most economic manner. To accomplish this in the face of international competition necessitates turning to account every possible asset. Two of the greatest of these are industrial education and scientific research. Their value at present is not fully recognised.

To appreciate how the press can cooperate in making their importance appreciated requires first of all a clear grasp of the fundamental principles on which these two factors depend, and a knowledge of the specific obstacles that at present hinder progress.

Education.

While agreeing in general with Dr. Garnett's suggestion as to the need for specific education to suit all grades of industrial employment, for my present purpose it will be sufficient to group these grades into two classes, namely, *manual* and *non-manual* workers.

For the latter, which comprises the higher ranks of employment, there are already some facilities, although these are inadequate. For the former, suitable education, in an industrial sense, is woefully neglected. I will confine my remarks on educational matters to this class.

The greater part of juvenile labour representing the future skilled workers in industry is at present a wasted national asset, since due to lack of suitable practical training, and especially of education co-ordinating with daily work, its capacity for production is very far from being developed to its utmost.

While much may be done by the careful selection of youths and some bias given to their general education which will fit them for entry into industrial life, it is of the utmost importance that a continuation education of a character applying specifically to their work be provided. It is not sufficiently realised that almost every youth in industry who commences as a manual worker will continue as such all his life, and while there are many opportunities for him to acquire education fitting him for higher positions, this is to a large extent thrown away on the youth who will remain a manual worker. The kind of education I have in mind is that which can best be applied actually in works, but which under modern conditions of industry cannot be imparted to a youth under ordinary conditions during his practical training. A few progressive firms have instituted works schools for this purpose, and in this direction either individually or collectively employers can solve the problem. The fundamental difficulty is that employers in the main do not realise to what extent the value of a worker can be improved by suitable training and education, or to what extent such an improved worker is an asset in facilitating economic production. Much good would result from the education of employers through the various technical and trade press in the different industries to a greater appreciation, not only of their responsibilities in connection with the education of the juvenile worker, but to a realisation of the asset he may become. Thus far the employer has been passive in the matter, and has looked to the educationist to deal with the problem. Its real solution can only come from the employer deciding what in his own interests is the best kind of industrial education his juvenile employees can have, and then making his voice heard in demanding that this kind of education be provided. Incidentally it should be noted that the development of a good workman is the best foundation on which education for citizenship can be based. It should further be noted that while some guidance can be obtained from the careful study of the methods adopted in other industrial countries, the whole problem is a psychological one which we have to solve to suit the characteristics and conditions of our own people.

Industrial Research.

Industrial research is spoken about so much nowadays that by some it is likely to be considered a sort of panacea for all industrial ills and its real function lost sight of. At the best industrial research can be considered only as a very desirable weapon—which manufacturers in this country have on the whole heretofore failed to make use of in their efforts to produce economically—and a means of providing new discoveries of science having application in industry.

The fundamental principle on which industrial research rests is that no industry can make progress without the continual addition of new knowledge. In earlier days this new knowledge was provided by the growing experience of the individual workers. This, together with results of the efforts of occasional inventors, ultimately became the common property of the industry. With the increasing complexity of industry and more exacting competitive conditions, this new knowledge became increasingly difficult to provide until far seeing capitalists appreciated the need for organising means and using every facility that science affords to provide a continual influx of knowledge. These men at the same time appreciated that sooner or later every scientific discovery finds its use in industry. It is along such lines that modern industrial research has developed, and its use in this country is necessary because it depends on this fundamental principle, and not merely because other countries have already taken advantage of the facilities it affords. While this is so, some guidance can be obtained from the progress our competitors have made. In Germany, for instance, the important feature arising from industrial research has been the great appreciation shown by manufacturers of the benefits to be obtained from the application of science, and the absorption into their industries of very large numbers of highly trained technical men. Particularly have the benefits of industrial research been seen in the chemical and electrical industries.

In the States an enormous amount of industrial research has been carried out by individual firms. Striking results may be noted in connection with the research work done by the General Electric Co. dealing with improvements in electrical apparatus; in the production of chemicals, and in the initiation of several new factories for the purpose of manufacturing products discovered in the research laboratory. In the National Electric Lamp Association Laboratory, Cleveland, a great deal of the modern developments of electric lamps has taken place, and in addition in the pure science laboratory there, pioneer work is continually being done in the science of illumination. The American Rolling Mill Co., one of the largest producers of sheet steel in the States, owes its important speciality—the production of rustless sheet iron—to the research laboratory. The Eastman Kodak Co. maintains its position in the front rank as a producer of photographic chemicals and apparatus largely as a result of the pioneer work carried on in its research department under Dr. Mees. The recent success in long distance wireless telephony has been achieved largely as a result of the investigations in the research laboratory of the Western Telegraphic Co. A new industry for the manufacture of commodities from synthetic resins had its inception in the scientific work of the General Bakelite Co. In other directions in the States great progress has been made through the investigational work of such companies as the Dupont Powder Co., General Chemical Co., United States Steel Corporation, &c., in fact at the present time there are many corporations having research laboratories, costing annually from £20,000 to £100,000 each for maintenance.

Apart from manufacturing concerns, important research work in connection with industry has been done by the Bureau of Standards, notably in connection with refrigerating machinery manufacture, and by such institutions as the Mellon Institute of Industrial Research, Pittsburg. In this latter institute—the work of which has been described on a number of occasions in the press—valuable industrial research dealing with glass production, smoke prevention, copper leeching, timber preservation, cement manufacture, paper products, &c., in many cases resulting in the commencement of new factories and in fact of new industries, has been carried out. Some of the most striking features of the research work in America are the lavish manner in which the laboratories have been planned and which in many cases enable large scale manufacturing operations to be carried out in order to determine the best possible methods of manufacturing any commodity developed or discovered in the laboratory; the appreciation of men of higher scientific training by industry, resulting in increasing numbers of students proceeding to their doctors degree before leaving the university; the increasing attention given in the research laboratories to pure science investigations, this being in my opinion the most important phase of industrial research; the absorption of men who have proven their capacity for industrial research in such places as the Mellon Institute, the Bureau of Standards, &c., by the various industries in which they have taken scientific interest.

In England our scientists have excelled in almost every field of pure science. In many isolated cases the discoveries thus made have been turned to account in industry. A notable example is that of the work of Sir R. Hadfield in connection with the production among other specialities of high grade magnetic quality sheet steel. Then again the whole of the electrical industry practically depends on the initial pure science investigations of the early electrical scientists.

From a national point of view, in order to utilise to the full the benefits of industrial research, it is necessary to organise these scattered individual efforts so as to present an organised front instead of operating as a number of units. As to the lines on which this can be done, there are many alternative possibilities, and personally I am of the opinion that our efforts should be concentrated in one central institution comprising laboratories, each of which serves as the focus for one of the principal industries, rather than utilise a number of scattered institutions. It is immaterial at the moment, however, what plan is followed, as long as it is devised according to sound fundamental principles and that existing facilities be modified to fit in with an ideal plan rather than the plan being modified to suit existing facilities.

Obstacles in the way of National Industrial Research.

No progress can be made in the way of instituting a national scheme of research without a great deal of preparatory spade work. The greatest obstacle that at present exists is the lack of appreciation by manufacturers of the application of science in industry, and the general tendency to avoid the employment of the scientifically trained men. To a considerable extent this attitude reflects the lack of the real fundamental knowledge of science that should have been acquired in early education, and also to a complacency arising from the fact that the British manufacturer appears to possess to a greater extent than his international competitors, a capacity for industrial organisation which in the past has been a most important asset.

Co-operation of the Press.

It is in the direction of educating the manufacturer to a proper sense of the value of industrial research that the press can do most valuable work. in fact it appears to be the only method by which the lethargy of the manufacturer can be dispelled. To accomplish this educational work, however, it is necessary that a definite propaganda be planned rather than a species of sniping carried out at occasional intervals. It would appear to me to be desirable that the press should be organised so that in each industry the principal organs can devote consistently space for the purpose, first of all of laying down the fundamental principles of industrial research; its economic importance as a weapon in meeting foreign competition, and by the adoption of new scientific discoveries outstripping competition; evidence of what foreign competitors are doing and the advantages they are achieving from research; examples of industrial research in this country and the general progress made by the more progressive firms in this respect. Through the principal trade organs the interest of the leading men in each industry could probably be enlisted to co-operate in this educational movement, and some good may result from the encouragement of correspondence on the matter in order to secure the view points of the people in industry.

Progress can only be made through the manufacturer being awakened to a realisation of the benefits that research can confer.

Quite apart from arousing some immediate interest in this subject, it is necessary to build far deeper and encourage increasing numbers of young men to secure sound scientific training with a view to entering industry. Particularly does this apply to those who will eventually inherit or occupy positions of importance in manufacture. Further, every effort should be made to divert into productive vocations those young men of ability who otherwise tend to pursue callings that have no productive value.

In planning an educational propaganda for manufacturers this might be facilitated and some scheme of working laid down by a conference between a few of the more progressive industrial people and representatives of the press. Ultimately it is likely, I should think, that separate organs for industrial education and research would be needed.

DISCUSSION.

In opening the discussion the CHAIRMAN mentioned that a telegram had been received from Mr. Hill, of the Scientific Organisation Association, regretting his inability to attend. Several prominent men of science had likewise sent letters expressing their interest in the meeting and regretting their absence owing to other pressing engagements.

Prof. R. A. GREGORY (*Nature*), who represented the British Science Guild, said that it seemed to have been forgotten or put aside for the time being that there is a difference between scientific investigation as generally understood, and industrial research. Usually the manufacturer, if he saw a way of making money out of the solution of a problem, would try to do something; that was industrial research, namely, research with practical profit in view. It was industrial research that made Edison send investigators all over the world to try to find a suitable filament for the first incandescent lamp. On the other hand, scientific investigation, which comprised all the best work that had been done, and had promoted the greatest development in engineering of all kinds and conferred the greatest benefits upon the human race, was done without any consideration of profit whatever. That was the distinction between the two. It was scientific investigation which had founded the electrical engineering industry; in other words, it was the researches carried out by Faraday at the Royal Institution in London, purely as a scientific study which had brought the electrical industry into existence. The greatest discoveries were not due to industrial research, which was a commercial matter, and could almost be left to take care of itself. If a royalty of 1 per cent. for scientific research had been put on all inventions depending on Faraday's work, there would have been available much more than the £300,000, which had been suggested by Dr. Garnett. Sir Ronald Ross's discovery of the cause of malaria, namely, that it is due to infection by the bite of a particular mosquito, had resulted from work which had no official sanction and was, indeed, discountenanced, yet millions of lives had been saved by the discovery. This work of Ross's had also been largely instrumental in practically stamping out yellow fever in the Panama Canal region, although he did not forget that the yellow fever investigation had originated in America after Ross's work on the mosquito. The true scientific man pursues investigation just where his fancy led him, and this was quite different from the research carried out with the object of finding a market for the result. With regard to the Advisory Council referred to by Dr. Garnett, this had been established in our usual fashion, and he, for one, was not impressed by it to the extent that Dr. Garnett appeared to be. It was under a Committee of the Privy Council, the members of which, except Lord Haldane, knew nothing about science. The Advisory Council was a very distinguished scientific body, but its officials did not come within that category. The Secretary of the Committee was Sir A. Selby Bigge, Secretary of the Board of Education, who did not pretend to have any knowledge of science. Then the Advisory Council had two secretaries appointed by the Board of Education, neither of whom had any particular scientific training, so that the very start had been made in an unbusinesslike way. If the Advisory Council was to be a living organisation, initiation by the executive officers was the great thing needed. The Government seemed to expect that men of science would come forward and help, and get nothing for doing so. Numerous committees had recently been appointed in connection with munitions and trade by societies and Government departments; and all the members were working for nothing. Men of science did not mind doing this during the war, but it seemed the general idea that they should be content to live on one or two hundreds a year, and provide the discoveries from which the manufacturers were to make their tens of thousands. Men of science did not propose much longer to be regarded as workers in garrets to be exploited, and it was necessary for the country to know this. Lawyers and other professional men did not give their services for nothing; neither the Attorney-General, nor the Solicitor-General, nor the medical consultants were working during the war for nothing, and therefore men of science should not be expected to do so. What was wanted was a Board or Institution in which all science would be organised and brought into connection with industrial work. Such a body should embrace, not only chemistry and physics, but all branches of science, and should take under its control not merely the National Physical Laboratory, but a national chemical laboratory and laboratories dealing with other subjects. We wanted a Board in which scientific work could be brought together and put into relation with the educational and industrial organisations of the Kingdom. At present there was a most deplorable neglect in the provision made for publication, and the United States was an example in this respect in the manner in which the Bureau of Standards issued its publications, which were prepared most admirably and distributed widely to the technical press, and through them to the public. On the other hand, our National Physical Laboratory reported once a year in a document consisting of only about 50 pages or so.

Mr. L. PENDRED (the *Engineer*) remarked that all the memoirs of the National Physical Laboratory were published.

Prof. GREGORY agreed, but said they were very few, and there was little comparison between the publications of the Bureau of Standards and those of the National Physical Laboratory. It was important to have very free publication of the work done at all institutions of this nature. While our Government had been considering what it should do, the Commonwealth of Australia had practically established such a scheme as he had suggested. This scheme, which provided for the constitution of an Institute of Science and Invention, had been drawn up by Mr. Hughes, the Premier, who was at present in this country, and when Mr. Hughes returned to Australia a Bill was to be presented in Parliament and the Institute established. We had got a lead from Australia and he hoped that it would not be long before we were able to follow very closely what was being done on the other side of the globe.

The CHAIRMAN mentioned that the proceedings at this meeting would be reprinted, published in pamphlet form and distributed.

Mr. L. PENDRED (the *Engineer*) said there were one or two points in Prof. Gregory's remarks which he would like to refer to. Prof. Gregory was under some little misconception as to the way in which the work of the Advisory Council would be carried out. He (Mr. Pendred) happened to know a little more than was generally known of what was being done by the Advisory Council, and he believed it would be found that the final arrangements were such as would appeal to the general body of British manufacturers. Then with regard to the publication of scientific reports in this country, reference had been made to what was done by the National Physical Laboratory. This laboratory worked on the plan of allowing the members of its staff to issue to the press articles upon the work done in the laboratory; that appeared to be a very excellent way of distributing the knowledge broadcast. It also issued annually a book containing memoirs on a considerable number of subjects. The very important work that had been done in aeronautics, on screw propellers and air resistance, had all been published in special form. It must be admitted, he thought, that the National Physical Laboratory had endeavoured to spread the knowledge it had acquired. He would also like to add that the work done at the Yarrow tank at Teddington had been published almost annually in the reports of the Institution of Naval Architects. Similarly, the work done in alloys research had been published before the Institution of Mechanical Engineers in papers presented by the Alloys Research Committee.

He was so thoroughly in agreement with Dr. Garnett and Mr. Fleming that there was little to discuss, so far as their papers were concerned, but one point he would like to draw attention to was that there seemed to be a considerable feeling that science was going to do everything for this country. We must not be led away by the notion that we could put reliance in science and science only. We did not want a very much larger number of scientific men than were turned out annually, but it was necessary to have a greater number of people who took a sympathetic interest in science. We did not want everybody trained as scientists, and he was very glad to see that Dr. Garnett in his sixth section laid stress on the value, for *certain* purposes, of a classical education. With regard to our associations and their work on research, Dr. Garnett stated that the British Association was the only one which had successfully attempted organised research. That, he thought, required a little modification. The Royal Institution, as all knew, had done a great deal of very valuable scientific research, for instance, Dewar's research into low temperatures. The work recently done also by the Institute of Chemistry was one of the most remarkable pieces of research work ever carried out. When the war broke upon us it left British manufacturers practically at a standstill for the lack of glass. It was impossible even to carry out the manufacture of guns, because we were short of a particular kind of glass. The analysis that was essential to the manufacture of steel had to be done in glass which all came from Germany and could not be supplied here. The Institute of Chemistry on its own initiative started a little research which was provided with £200 as funds. Later he believed the Advisory Council advanced an additional £500, and with that money the Institute of Chemistry—which had appointed Prof. Jackson of King's College to carry out the research—had produced a series of formulae for glass which enabled manufacturers to produce any glass required both for optical and laboratory work. He regarded this as a wonderful piece of work, in view of the fact that it had been accomplished in about six months.

Dr. R. MULLINEUX WALMSLEY (Principal of the Northampton Polytechnic Institute) could only offer a few disjointed remarks in the limited time available. He said that we had been treated during the last few weeks in the press to an anti-German campaign, and directions as to what we were to do to obtain German trade after the war. What Mr. Fleming had told us about America, however, indicated that we must look westwards as well as eastwards, for we should have very much keener competition in the first years after the war from the other side of the Atlantic than from Germany. If we neglected the lessons taught by Mr. Fleming's remarks with regard to industrial research in the United States, we should suffer for it very seriously. He would like all journalists to keep that in mind; they could wield an enormous power in helping to meet that competition, which would probably have to be met by methods different from those which were promulgated to deal with the competition from the East. With regard to classical education, he would have very much liked Dr. Garnett to have gone further and to have said that our classical men, without neglecting their classics, should have a great deal more science. Notwithstanding their lack of science, however, one form of research had been highly developed by them, but it was not beneficial to the country, namely, the synthetic production of red tape. He could not agree that industrial research could be neglected. Industrial research had come to stay. He thoroughly agreed with all that Mr. Fleming had said on that point, and we had got to face it. It would be well for all those interested to do what Mr. Fleming had done, namely, take a trip to the States and see what was going on there in this direction on the spot. One point in Dr. Garnett's paper called for a little bit of caution, namely, the suggestion that teachers should learn trades. He hoped Dr. Garnett did not really mean that teachers should learn trades because he thought that if a teacher were set to learn something about industrial things, the temptation was for him to begin to think he knew all about the particular trade involved, and this would be mischievous. He would like to close with one more remark on the subject of industrial research. He had been approached during the last two or three days, and had agreed to allow one of his staff to be taken away from him to found a research laboratory in a works. He had been lent for twelve months for what was essentially industrial research, and it was hoped that he would come back again to educational work, although there might be some doubt about that.

Mr. W. R. COOPER (editor of the *Electrician*) agreed with Prof. Gregory that it was necessary to cultivate pure science and the scientific man who investigates as the spirit moves him. With regard to the branch of research carried out by manufacturing firms, some people looked upon that as undesirable, and thought that manufacturers should not keep their own secrets. He could not agree with that point of view. Manufacturers were bound to go in for trade secrets, particularly in chemical work, because if a process was patented too much might be disclosed; hence the necessity in the chemical industry for keeping things secret. As Mr. Fleming had remarked, this sort of work required a good deal of money to carry out, and it would have been carried out in this country by manufacturers on a larger scale in the past if they had had more profit than was the case. Profits in many cases had been negligible, and it was quite impracticable to spend 5 per cent. of the profits when there were not any profits to distribute as dividends. The third class of research was industrial research on broad lines with State aid. This was a class of work which could not be taken up by either the pure scientist or the manufacturer. In this category could be mentioned such work as insulating materials and the dissipation of heat in rotating machinery. Dr. Garnett had mentioned State patents, but he must confess that he had not any faith in that class of thing at all, because when it came to licensing more than one individual it was really impracticable from the commercial point of view. Anyone who had a licence had to spend money to get a market, and if the market was to be divided up between two or three people, A would not spend money because he thought B would benefit by it and firm C likewise. He agreed with industrial banks, although we could not expect our existing banks to go in for such work. One of the greatest difficulties in launching new things was the financial one, and if the company promoter could be eliminated it would be a great advantage. At the same time the British manufacturer should have a little more go in matters of this kind. At present when the manufacturer saw something new, he was satisfied with the fact that he was earning money at the moment on something else, and he therefore neglected the new product which would not bring him in money for, say, two or three years. He allowed a few years to go by with little effort, and then after fourteen years when the patent expired he asked for a renewal. There must be more industrial education, and it must be on the right lines. It was contrary to human nature to expect youths to put in several hours per evening at schools after eight or nine hours in the shop. He had tried it himself, and he was sure that good results could not be expected from that kind of thing. The employer must look at it from a higher standpoint. With regard to the press, he did not quite know what was in the mind of the meeting. In his opinion, there were two or three spheres for the press. First there was the question of education, and that applied quite as much to the lay press as to the technical press. If we did not get the man in the street to appreciate science it was not much good. Even if he were made to believe in perpetual motion it would be better than nothing, for it would raise his interest in science. Without this appreciation we should never get any grants from the Government, for in addition to there being ignorance on the part of the man in the street, there was also ignorance on the part of people in Government offices who ought to know better. The second point for the press was to give publicity, and for that purpose it should certainly be in close touch with the Privy Council Committee or the other Committee, whichever might be best, whilst a third function was to criticise. If there was to be any collective action it must be on broad lines. It was not the part of the press to originate anything in the way of research. That must be left to technical societies.

The CHAIRMAN, in closing the discussion, said that the subject was obviously one of very great interest to the Circle, and he hoped that several meetings would be devoted to its continued discussion, so that the various points raised in Dr. Garnett's paper and the remarks made by various speakers could be fully considered.

He would now call upon Mr. Gilbert Wood to propose a resolution expressing the views of the meeting.

Mr. GILBERT WOOD said the resolution he had to propose was in three sections, as follows :—

(1) *That this Meeting recognises that Technical Education and Industrial Research are of great benefit to the manufacturers of the country.*

(2) *That the Circle of Scientific, Technical and Trade Journalists is prepared to assist the promotion of unity of effort on the part of the various associations and committees engaged in the study of this subject.*

(3) *That the Scientific and Technical Press be used as a medium for the dissemination of information of value to the industries of the country, thus bringing about a fuller appreciation of the value of Technical Education and Research.*

Mr. J. S. DOW, briefly seconding the resolution, said that the greatest need at the moment was to raise the standing of scientific work in the public mind—to educate manufacturers and the public to believe in the existing scientific and technical organisations, and give them fuller support. People who criticised our institutions and colleges of this country were apt to forget how very much greater were the facilities given abroad. As an instance Mr. Dow referred to the great technical schools of Germany and the marvellous educational organisation in Switzerland, a little country with a population less than that of London, but having no less than seven important Universities. Mr. Dow also recalled a Report by Dr. Gregory in the *Journal of the British Science Guild* last year, in which figures for the support given to applied science in various countries were quoted. There was one Institution in the United States which alone received each year for the prosecution of scientific work twice as much as the total official grant for scientific work of all kinds in this country.

He hoped that the work of the Circle would have a useful influence in promoting a better appreciation of the value of applied science ; the creation of this feeling was a necessary preliminary to any real progress towards the full utilisation of our scientific resources.

Dr. GARNETT, briefly replying to a few of the points in the discussion, said that our present Patent Law system was too much regarded by patentees merely as a means of granting monopolies, whereas the true purpose of the Patent Laws was to grant such protection only as would make it possible to manufacture the new invention, and that was the point he had in mind when speaking of this matter. Dr. Walmsley had stated that he did not want secondary school teachers to be taught a trade. He (Dr. Garnett) entirely agreed, but would like to send such teachers to Dr. Walmsley for a year to have the run of his technical classes and work in his laboratories, because he was sure the result would be to the general benefit of the boys with whom those teachers had to deal. Mr. Pendred had pulled him up for saying that the British Association was the only body which had been successfully organising research. He admitted that he ought to have been careful to explain that he did not mean to include in this the valuable work done in organising scientific work since the war broke out. At the beginning of the war a big optical firm came to one of the London schools to borrow 2 lb. of barium crown glass to enable them to complete an Admiralty contract, but not many months after he saw a 60 lb. lump of beautifully clear barium crown glass which had been made as the result of some of the combination of science and industry which had been brought about during the last few months. Neither did he include in his remarks such work as that done by Sir James Dewar or any other individual worker. He referred to the work done by such Committees as the British Association Electrical Standards Committee which on occasion had rendered most valuable service *in organising combined scientific research.* Prof. Gregory had distinguished between scientific investigation and industrial research and he was sorry if he had made any confusion himself between them because he had the clearest definition in his own mind between the purposes of the two, though in practice they frequently overlapped. It was with a clear view towards a definite industrial result in connection with synthetic indigo that the Germans spent a million of money before they destroyed our Indian indigo industry. What was wanted was a Council to advise, organise and aid industrial research, so that we could render of commercial value quickly all scientific discoveries. There had been too long intervals between the earliest scientific discoveries in this country and their practical application.

Mr. A. P. M. FLEMING also briefly replied to the discussion. He had been much struck by the fact that in many laboratories in the United States men who were engaged in regular industrial research work were also carrying out investigations in pure science. Therefore, while he agreed with Prof. Gregory that there was a distinction between the two, both forms of research were often undertaken simultaneously in the same laboratories.

Another point was the collection and dissemination of information. In addition to the Bulletins of the Bureau of Standards, data were distributed by a number of University experimental stations throughout the United States, and the publications of the Department of Agriculture, in particular, furnished an excellent example of work of this kind.

RESUMPTION OF DISCUSSION ON MAY 16th.

The discussion was resumed at a meeting held in the Hall of the Institute of Journalists, at 5 p.m., on Tuesday, May 16th, the Chair being again taken by Mr. L. Gaster, who delivered an introductory address, summarising events of importance in relation to the organisation of science since the last meeting on March 14th.

Mr. Gaster remarked that there was in this country a growing recognition of the value of applied science. As a preliminary to future progress it was, however, essential to educate public opinion to appreciate more fully the benefits of research so that the country might be prepared for the labour and sacrifice which scientific organisation demands.

The scientific press, which reaches such a variety of industries, could do good work in this direction, and also by promoting unity of effort on the part of those interested in the organisation of science. These two aims were expressed in the Resolution passed at the last meeting.

But in order to carry out their aims journalists should themselves become students, keep themselves informed of the latest progress, and understand something of the fundamental principles of education. Dr. Garnett and Mr. Fleming had placed before the Circle a very comprehensive survey of the subject at the last meeting and he proposed to give a short summary of various proposals for the improvement of technical education and the organisation of scientific research, up to the date of the present meeting. Public interest in the subject had developed mainly about the middle of the last year. The scheme for the Organisation of Industrial and Scientific Research, under the Privy Council was announced at the end of July, 1915, and the preliminary arrangements were doubtless made a considerable time earlier. Those who were inclined to criticise the Government for the neglect of science should, therefore, in fairness recognise that although much remained to be done they had taken steps at quite an early stage in the discussion.

Among events of importance during 1916 may be mentioned :—

The Memorial, signed by 36 leading men of science, advocating fuller representation of science in the service of the State, and ultimately a Ministry of Science, Commerce and Industry .. .. .. *Feb. 2nd,* 1916.

(This Memorial was afterwards endorsed in an Appeal from the Imperial College of Science .. .. *Feb. 21st,* 1916.)

A Paper on the Organisation of Scientific Research was read by Professor Fleming before the Royal Society of Arts *Feb. 9th,* 1916.

The last Meeting of the Circle of Scientific, Technical and Trade Journalists, at which Dr. Garnett's paper was read, took place on *March 16th,* 1916.

A meeting attended by representatives of the chief scientific and technical societies was called by the Royal Society and a Resolution passed empowering the committee to draft a scheme for a Conjoint Board of Scientific Societies, in order to promote the co-operation of those interested in pure and applied science, encouraging the application of science to industry, &c. .. .. *March 22nd,* 1916.

An account of the work initiated by the Advisory Council of the Committee of the Privy Council on Industrial Research was made public, mentioning research and grants allotted for experiments on tests of hardness, composition of alloys, laboratory and optical glass, methods of extracting tin and tungsten, &c. *March 24th,* 1916.

A further paper on Engineering and Scientific Research was read by Prof. J. A. Fleming before the Society of Engineers on *May 1st,* 1916.

A meeting was called by the Neglect of Science Committee, and a Resolution passed urging that the natural sciences should form an integral part of the education of the country, and that a knowledge of them should be required in the Civil Service and by candidates at Sandhurst .. .. *May 3rd,* 1916.

A further statement of work done in connection with the Advisory Council of the Committee of the Privy Council was made at the first meeting of the Standing Committee on Metallurgy, when Sir Robert Hadfield gave an addrsss advocating the extension of metallurgical research, particularly in regard to the production of special steels, methods of hardening, the application of photo-micrography, high temperature measurement, &c. *May 8th,* 1916.

The above statement by no means exhausts the number of proposals, and the broad question of correlating the investigations being made independently by many societies, colleges, and institutions throughout the country requires full discussion.*

Mr. Gaster added that there were present several gentlemen who had taken a great interest in these questions, and they hoped to hear their views in the course of the discussion. Among others, Lord Rayleigh, Lord Sydenham, Lord Montagu of Beaulieu, Sir Phillip Magnus, and Sir Harry Johnston had written expressing regret at their inability to be present. A letter had also been received from the Secretary of the Royal Society, explaining that the proposals for forming a Conjoint Board of Scientific societies are in embryo at present, but approving the co-operation of the scientific and technical press in regard to these matters.

The great need in this country is the co-ordination of separate efforts and the development of an organisation for more effective co-operation between scientific and technical men. With a view to promoting such co-operation it was desirable that individual proposals should be fully discussed in the press at an early stage. Moreover such co-operation need not be limited to this country. It is desirable to associate the efforts of workers in other parts of the world. One of the most interesting events during recent months had been the Conference called in Melbourne to consider a scheme for a Federal Institute of Science and Industry. Mr. Hughes, the Prime Minister of Australia, had kindly consented to be present at the meeting, and they hoped to hear from him something of the important scheme proposed by the Australian Government. These proposals had for their object the organisation of applied science and industrial research throughout Australia, and included the establishment of a Bureau of Information for the interchange of experience between manufacturers and men of science. The progress of the scheme would be watched with keen interest in this country.

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* (On the day following this meeting (May 16th) the Tenth Annual Report of the British Science Guild was issued. The Science and the State Committee of the Guild is stated to be considering the question of obtaining for science " a more generous recognition " in public affairs, and a Report on the matter will be published later.—ED.)

In conclusion Mr. Gaster said that his object in making these remarks had been to supplement the addresses of Dr. Garnett and Mr. Fleming at the former meeting, by a synopsis of recent events in part directed towards the practical realisation of the aims set forth in those papers.

He had much pleasure in calling upon Professor R. A. Gregory to open the discussion.

Professor GREGORY then read in abstract the following communication :—

EDUCATION, SCIENCE AND INDUSTRY.

By PROFESSOR R. A. GREGORY.

Three prime points to which attention should be directed may be distinguished in Dr. Garnett's paper, read before this Circle at the meeting on March 14th ; they are :—

(1) More practical studies, and less academic instruction, in all schools, and an increased number of specialised technical institutions, as well as of advanced students of technology.

(2) Adequate encouragement of scientific research and provision for its application on a commercial scale.

(3) Co-operation between Trade Association and the Advisory Council on the Development of Scientific and Industrial Research, as well as with the laboratories of local technical colleges and universities.

Education, science, and industry are respectively represented by these three points ; and the co-ordination of the efforts of them all is required in order to reach the common end.

The need for more scientific teaching in elementary schools was stated by Mr. C. W. Crook in his recent address as president of the National Union of Teachers. "What is needed," he said, "is the scientific spirit, which should, and must, direct the teaching of all subjects, not omitting the essentials of formal English, so that our children may proceed to sound judgments by accurate reasoning upon clearly viewed facts."

As regards research, it may be divided conveniently into two classes—one in which the motive is solely the desire to extend the boundaries of knowledge, while in the other the special purpose is to obtain results which have a direct bearing upon problems of manufacture and construction. Purely scientific investigation has, however, led to some of the greatest industrial advances, as, for example, the development of electromagnetic machinery from Faraday's experiments, and wireless telegraphy from the work of Clerk Maxwell and Hertz.

Industrial research, that is, research from the point of view of commercial profit, may come out of purely scientific investigation ; and belief in the value of each is necessary for national advance. In the field of great discoveries in science, Great Britain takes a leading place ; but in industrial research manufacturers in the United States and Germany are easily ahead of us. The result is that opportunities for highly-trained technologists are more favourable there than here. It has been estimated recently that for each 1,000 chemists in Germany, there are only 24 in England, where a chemist is unlikely to receive a greater salary than that of an intelligent artisan or clerk. Largely on account of the poor prospects of technically-trained men in the British Isles, the number of students of advanced science and technology is far less than in Germany. As the Report of the Board of Education pointed out last year, "the provision for full-time education in applied science is regrettably small in bulk compared with the industrial development of the country."

Manufacturers are beginning to appreciate the value of science to industry. At the last meeting of the Central Executive Committee of the Employers' Parliamentary Association a resolution was passed urging the necessity (1) of increasing the number of chemists trained in research work, and (2) of making special efforts to enlist the co-operation of manufacturers who hitherto have been lamentably apathetic in regard to scientific industrial research and training. The first of these results can be attained by increasing the position and prospects of men who devote themselves to the study of chemistry; and the way to effect the second is to see that everyone —particularly men who are to become masters of great works on account of family relationship or influence—receives a certain amount of scientific education. The possibilities of science can only be appreciated by people who have had instruction in scientific subjects; and the lack of such instruction in the courses mostly followed in the public schools and the ancient universities is our chief defect in the training of capitalists, manufacturers, and legislators.

By organisation, by co-operation among our manufacturers, and by education in science of directors as well as artisans, industrial advance can be secured. At present, science, industry and education are working in separate fields, whereas their efforts should be combined. The Royal Society, with a number of other scientific societies, has established a Conjoint Board for the purpose of organising scientific effort in this country; and similar organisations of technical experts have been brought together by engineering societies. The British Association is obtaining from each of its sections views as to the assistance which they may afford to national development. Sir Ray Lankester has obtained a distinguished body of opinion in favour of a change in the position of science at the public schools, at Oxford and Cambridge, and in the examinations for the public services; and the Re-organisation Committee, of which he is chairman, is limiting itself to this field. An Education Reform council has been formed to deal with all branches of education in relation to modern needs; and various commercial and industrial bodies have passed resolutions relating to education and science as essential factors of progressive industry.

What seems to be particularly needed is a combination of the forces of education, science, manufacture, and commerce, instead of the separate representation of these interests. The British Science Guild exists for this purpose; and it has upon its committees and among its members leading representatives of all these interests. Membership is open to every British subject; and all who believe in "the necessity of applying scientific treatment to affairs of all kinds" should strengthen the influence of the Guild by joining. When opinion is united as to national needs, it will be possible to secure the reforms now urged separately by education, science, and industry.

The Advisory Council may do much to promote this combination; but its constitution and functions should be greatly widened if they are to embrace the whole of the British manufactures, except rural industries, which are provided for by the Development Commission. It should eventually become a Board of Science and Industry, such as has been established by the Commonwealth of Australia, and be directed by men of high business capacity and scientific knowledge. Such a Board would serve as a scientific intelligence department, and would, among other matters, promote the co-ordination of industrial effort, secure connection between manufacturers and the laboratories of universities and colleges, and distribute information of a scientific and technical character. It would, in fact, perform most of the functions of the Ministry of Commerce, recommended by the Sub-Committees of the Board of Trade in its recent report on British trade after the war.

Sir JOHN COCKBURN said that the enormous strides which Germany had made in science and industry rested for the most part upon ideas which had been initiated in this country, while it was a further fact that for years past Great Britain had, so far as industry was concerned, been gradually falling into the hands of Germany. It was indeed by the exploitation of our trade that Germany had acquired the wealth which tempted her to provoke the war. Consequently unless we took steps to put the application of science and industry on a sounder footing we should find after the war this process still continuing and the Empire placed in still greater jeopardy by the coming industrial war than by the present terrible conflict.

He fully agreed with the great importance of making instruction not only in elementary schools and secondary schools, but in the technical schools themselves more practical. Thirty years ago in Australia he studied this matter and found excellent results followed from changing applied mechanics from a classroom subject to a workshop subject.

He wished to emphasise one point and that was that many drawbacks from which our industries suffered were not due to any inferiority in our technical schools because they were equal if not superior to anything in Germany; but the one great advantage that the German technical schools had was that when the students had completed their course they had a career open to them, whereas in this country they found themselves in a blind alley. It was no use training students technically unless there was scope for them afterwards to utiliss their accomplishments. One might as well attempt to teach swimming without water in which to exercise the art, and although we might possess technical schools of a magnitude and excellence unsurpassed by the world our efforts would be for ever vain unless steps were taken to render those great scientific industries which this country had lost safe from foreign control and usurpation in the future.

The manner in which the dye industry was lost to this country was an instance of the greatest neglect and want of foresight on the part of the authorities. It was much to the credit of the Technical Circle that they should have taken this matter up and he hoped that the result would be a correction of the faults of the past generation which had prevented students from reaping the just reward of their labour in after life.

Mr. GERALD LIGHTFOOT, Advisor to the Ministry of Australia, first apologised for the absence of Mr. Hughes, who had been prevented from attending the meeting, the more particularly as this subject was one in which Mr. Hughes had himself taken the initiative.

A conference had been convened in Australia by the Government, comprising not only the leading scientists, but also the representatives of industries with a view to formulating some scheme for the promotion of scientific research and the application of science to industry. That conference took place in January last before Mr. Hughes left Australia for England, and a committee was appointed with a view to formulating the general outlines for a scheme for the consideration of the Government. A Report was presented by the Committee, but the scheme had not yet been adopted by the Government, because Mr. Hughes desired to obtain information as to what was being done in America and England before the Government came to a decision. Nevertheless, matters had already been put in train in Australia, and an assessment was being made by a provisional committee of the existing personnel and material with regard to scientific work in order to coordinate the existing facilities and to set on foot some investigations in relation to our most pressing industrial problems.

Briefly outlined, the Australian scheme proposed to establish a Federal Institute of Science and Industry. The organisation would consist of an Advisory Council of nine members with an executive directorate of three members. One of these three, the Chairman, would be selected not necessarily because he was a scientist, but because he was a man who, in the course of his experience, had acquired an appreciation of the application of science and industry, a man of wide ability and experience. The other two members would be selected mainly on account of their scientific qualifications, and also on account of wide experience. These three members would confer with the Advisory Council, but they would not necessarily take the advice of the Advisory Council, because the whole responsibility of the executive administration would be cast upon the executive directorate of three. The directors would be free from political control, and the members would be appointed for a period of about seven years: the members would practically be on the same status as the judges of the High Court of Australia, being paid salaries of between £2,000 and £2,500 per annum. These would be removable only by resolution passed by both Houses of Parliament.

The scope of the Institute would be not only to deal with the secondary industries, but also with the primary industries, including agriculture, the pastoral and horticultural industries, as well as mining and metallurgy. One of the most important functions of the directors would be to go about the country and inform themselves either by technical evidence or with the co-operation of sub-committees of technical and scientific societies as to what problems should be taken up for investigation. It would be their duty to allocate the work of investigation to existing institutions, such as the universities and other laboratories. Then the Federal Government would furnish liberal grants to enable the work to be carried out. In this way it is hoped to stimulate and co-ordinate scientific work in the Universities.

The second main function of the directorate will be to establish a bureau of information, the duties of which will be not merely to disseminate information, but to collect it also for the benefit of the manufacturers and industry generally. A vast amount of information is available, and there is no reason why it should not be made available with the result that productions would be increased enormously.

Thirdly, in the course of carrying out this work, it is considered that the directors will no doubt come to the conclusion that certain important investigations of a fundamental character should be carried out, and it would be their duty to recommend the establishment of federal institutions, which would be liberally endowed by the Commonwealth Government. It was somewhat early at present to indicate what the nature of these institutions would be, but it was thought that there would be at least a national physical laboratory and national chemical laboratory. The opinion was that the field should be divided into physics, chemistry, and engineering, and each of these would have to be considered and dealt with separately. Very fine laboratories had already been established and equipped at the Universities. Some sort of agricultural organisation would have to be established perhaps somewhat on the lines of that at present at work in America, which appeared to be exceedingly efficient. The Government would co-operate with the existing institutions such as the Universities, and every endeavour would be to promote co-operation, not only between the learned and scientific societies, but also between the employers' associations.

Mr. Lightfoot attached much importance to the establishment of a scheme on an Imperial basis. Inquiries he had made in England led him to believe that the first step that must be taken before the Imperial co-operation could come into effect was the organisation of some central authority in England. This was essential before any steps could be taken to promote any organisation on an Imperial basis, and if this were done there were institutions in England which were most admirably equipped for certain classes of investigation. If some scheme of co-operation were established many problems of a pressing nature might be solved, to the mutual advantage of England and the Dominions. He had in mind the Metallurgical Department of the Sheffield University and the Textile Department of the Leeds University. An Imperial scheme should provide for a central clearing house from which all the information available would be distributed, a scheme of this nature should lead to great efficiency and to the elimination of waste of money, and duplication of effort.

At this point the Chairman, after thanking Mr. Lightfoot for his remarks, read a telephone message just received from Mr. Hughes's secretary to the effect that Mr. Hughes greatly regretted his unavoidable absence, but had been called away on important national duties.

The Rt. Hon. ARTHUR DYKE ACLAND said the great difficulty in this matter was to make public opinion understand that education is really an asset of national welfare and prosperity, but he believed the time was coming when the public would be convinced that this was a matter which deserved the attention of the whole State, and particularly Parliament. He recommended the Circle from this point of view to concentrate upon certain definite recommendations which should ultimately be brought before Parliament, because if the House of Commons could be convinced a very great public service indeed would have been rendered.

He recalled the efforts which had been made by a small band of people during the last thirty years to bring about an improvement in the secondary education of the country. He said it was interesting to remember as an illustration of our haphazard ways that the first important sum allotted by Parliament to technical education often called the whisky money, about three-quarters of a million a year had been intended as compensation money for the brewers and distillers. As regards the advisory Committee to the Privy Council on Industrial Research, he knew that the Committee would be largely left a free hand, and that the Privy Council Committee itself would desire not to interfere.

The great thing that was wanted was more money if the work was to be successfully done, and if leaders of industry would really believe that science was going to help them a very great deal more money should be available than the £40,000 at present voted to the Privy Council Committee. He was not in favour of the appointment of a Royal Commission to deal with these problems, because it was necessary to move in a much greater hurry than a Royal Commission usually permitted.

After paying a tribute to the magnificent equipment of the Imperial College of Science, Mr. Acland urged the necessity for providing greater facilities by way of scholarships for boys in the elementary and secondary schools, many of whom, he said, had greater intellectual abilities than others more fortunate in their social station in life. On this other question of class education he urged that Oxford and Cambridge should not be allowed to bar the way with their compulsory Greek, and he wished the Circle could persuade Parliament to take these things up and not be afraid of Oxford and Cambridge in this matter. The best men at these Universities had longed for reform for generations, and Parliament should be asked to legislate to remove some of these obstructions. Hitherto we had been too much afraid of the vested interests. Full efficiency in Government would never come until those in the Civil Service, the House of Commons, and even Ministers themselves were men who appreciated the value of a scientifically trained mind.

Teachers in secondary and technical schools also were badly underpaid, and a million a year could be spent usefully in improving the salaries of these teachers, and in giving the boys of sixteen and upwards a very much larger supply of Government bursaries and scholarships. Germany gave State grants to her University of about a million a year, whereas our grants to the Universities amounted to only £300,000.

Mr. A. J. MUNDELLA, as Chairman of the London District of the Institute of Journalists, congratulated the Circle on the excellent work it was doing. A point in Mr. Acland's speech which appealed to him was the need for more scholarships for the boys in lower class schools, and he hoped that in the propaganda for the extension of scientific education special consideration would be given to them. At present 92% of our children went through the public elementary schools and surely it could not be said that the scientific intellect would be found only in the others. He contended that in the children of what was called "the elementary school class" there was material for scientific training which would give as good results as were obtained from the education of the 5% whose social position enabled them to go to other institutions.

Mr. A. A. CAMPBELL SWINTON, representing the British Science Guild (*communicated*) :—For the reason, as I suppose, that historians are usually not scientific men, histories in most cases give a very misleading account of the chief factors that have influenced the progress of the world. True, if we go back far enough, and survey the little we know of history in the time of prehistoric man, we realise that, so far as those very distant epochs are concerned, the predominant influence of such science as then existed, is recognised by the fact that we talk of the Stone Age, of the Bronze Age, and of the Iron Age, to denote those vast periods during which the primitive inventor was discovering the means of applying new and improved materials to what was then the great necessity of man, namely, weapons for the chase and for defence and offence against his enemies.

Coming, however, to more modern times and surveying the forces which have directed the civilisation of the world, say, during the last thousand years, we find that, though during this period there have been sanguinary wars, great political upheavals and vast revolutions, and at the same time there have lived great kings, successful generals, and far-seeing statesmen, all of whose doings you will find fully described with an enormous amount of detail in hundreds of histories ; still, if you wish to know what are the three things that in the course of the last millennium have had paramount influence on the history of the civilised world, and have had most effect in producing the material conditions under which we live at the present time, they are not the work of rulers or leaders at all. On the contrary, they are scientific inventions, namely, the invention of gunpowder, the invention of printing, and the invention of the steam engine.

The first of these, the invention of gunpowder, entirely changed all the conditions of warfare : it did away for ever with the knight in armour, and with him the feudal system, and precluded for all times the recurrence of what occurred when Roman civilisation was overcome by the barbarians.

Then again, the invention of printing was the soul of the Renaissance, and of the revival of learning ; while who can exaggerate its effects on the diffusion of every description of knowledge ?

Finally, in the steam engine, with the resulting railway and steamship—none of which would probably have yet seen the light had it not been for the impetus that was given to every kind of endeavour by printing—we have an invention to which we owe all the major differences between the lives which civilised men live to-day, and those they lived a century ago.

There are also more modern inventions, such as the telegraph and the telephone, which to-day have an enormous influence upon the conditions of our existence, while still more recent are wireless telegraphy, and aviation, the possible developments of which are beyond what we are at present able to estimate.

What, however, I wish to emphasise is this : it is not the ruler, it is not the statesman, or politician, it is not the great soldier or sailor, nor is it all these in combination, who really direct the course of civilisation. In the case of these leaders of men most of what is accomplished by one man is sooner or later rendered nugatory by another, while much more potent in the long run than anything that they can do, is the work of scientific discoverers and inventors. These latter work for the advantage, not of one nation against another, but for the benefit of all mankind. Moreover, the results that they effect, are cumulative, and so far as they are not limited by the duration of human existence, they are everlasting. It is for reasons such as these that there is to-day a feeling abroad that more science should be taught in our schools and universities, and that scientific research and invention should be further stimulated in connection with all our industries.

Dr. GARNETT, replying briefly to the discussion, first moved the following Resolution :—

That this meeting urges upon the various Associations, Institutions and Committees engaged in the consideration of Technical Education and Industrial Research the necessity for co-operating in order to present a National Scheme for the consideration of the Government.

That in any measures taken for the preparation and execution of such a National Scheme the co-operation of the Scientific and Technical Press should be secured.

That this meeting is of opinion that the Press should use its influence to encourage the teaching of Science in Schools and Colleges of all grades, and to determine the proper position of Science in Civil Service and other examinations, especially with reference to the influence of these examinations upon Education.

That in the meantime it is desirable that all possible support should be given by the Press and the Public to the work of the Advisory Council to the Committee of the Privy Council for the organisation and Development of Scientific and Industrial Research, and that Industrial Associations should report to the Advisory Council on the facilities required for the conduct of Research in connection with their particular industries.

Nearly everything that had been said in the discussion was in accordance with the views he had attempted to express, and consequently he had little to answer. There seemed to be a concensus of opinion that in this country we are quite ahead of the world with regard to purely scientific research from which great industrial developments immediately come, but a long way behind Germany and the United States in connection with that form of industrial research which takes up a discovery and adapts it to the requirements of industry and commerce. It was in this latter connection that considerable help was necessary from the Advisory Council for Research. With regard to the criticisms that had been made of this body it should be remembered that both the Board of Education and the Board of Trade started as a Committee of the Privy Council. This seemed to be our way of doing things, and when the Committee had earned its footing the authorities allowed it to develop into a department of the State under a special Minister. He was not at all sure that we did not obtain advantages in that way in the early stages because such a body was less under political control than if it were under the direction of a Minister responsible to Parliament. Scientific Societies, and more especially trade associations should utilise to the utmost the opportunities which were afforded by the Advisory Council, at any rate until we got something better, if ever we did.

A great deal had been heard about reform in regard to science subjects in Civil Service and other examinations, and the reform of these public examinations was most important on account of the enormous influence which they exerted on the educational curricula of our schools. At the same time we must clear up our ideas as to what was meant by the position of science in Civil Service examinations. Those going in for high positions in the Civil Service should not only have a general knowledge of English literature and some modern languages but a general knowledge of science, the special subjects in any particular examination being adapted to the work for which the individual was intended, as for instance the telegraph and engineering departments of the Post Office, and so on. Thus while all Civil Servants would have a general knowledge and appreciation of science, the *competition* for the scientific appointments in the Civil Service would be in science and the allied subjects, and no question would ever arise as to the relative credit to be given to chemistry and Greek.

Mr. H. J. P. BENN seconded the resolution proposed by Dr. Garnett, and the resolution was put to the Meeting and carried unanimously.

The proceedings terminated with a vote of thanks to the Chairman.

VISIT TO THE IMPERIAL COLLEGE OF SCIENCE.

FOLLOWING the discussion summarised in the preceding pages, members of the Circle and friends paid a visit to the Imperial College of Science (South Kensington) on May 31st, at the invitation of the Rt. Hon. Arthur Dyke Acland, Chairman of the Executive Committee. The party was received and addressed by Mr. Acland and the Professors, several of whom gave interesting particulars of research work carried out since the outbreak of war. Professor Baker, in the chemical department, referred to several particularly important investigations which, although carried out originally in the laboratory on quite a small scale, had been conducted with a view to their subsequent application under practical conditions, and had led to most important developments.

Mr. Acland drew attention to a Memorandum which had just been prepared and signed by the staff of the College and addressed to Lord Crewe (the Chairman of the Governors). The Memorandum emphasises the vital importance of securing a fuller recognition of science in education, and the urgent need for additional support for the development of research, particularly in the matter of founding bursaries for gifted youths of 16—18 years of age, from whom scientific workers should be recruited. It is pointed out that while in Germany the State issues grants to universities of the value of about one and a half million each year, in this country the corresponding amount is less than a quarter of a million.

The visitors were then conducted over the laboratories and workshops of the College, which now extend over a considerable area. Great interest was expressed in the well-equipped chemical laboratories, the electrical and mechanical engineering departments (City and Guilds section) and the working examples of mineral-separation plants and other metallurgical operations. A visit was also paid to the research laboratory on combustion, where Prof. Bone gave a short account of the investigations being made on fire-clay and other matters. To many of the visitors it came as a revelation to find what a variety of work was already carried on and how great were the future possibilities of the College.

Subsequently the party was entertained to tea by Mr. Acland and the Professors. A vote of thanks to the hosts was proposed by Mr. Gaster (Chairman) and seconded by Mr. Gilbert Wood. Mr. Acland expressed the hope that the visit would be helpful in promoting closer co-operation between the press and men of science, and in fostering an interest in the Imperial College of Science as a great national institution, in which they might all take a legitimate pride. He also extended an invitation, which was endorsed by the Professors, to members who wish to receive fuller information on the work of particular departments, to make arrangements for a further visit with the Professor in charge, who would be only too glad to offer every facility.

INDUSTRY, EDUCATION AND RESEARCH.

THE attention of members of the Circle may be drawn to an important paper on the above subject, read by Dr. W. Garnett at the Annual Spring Meeting of the Textile Institute on May 5th. The paper discusses many of the subjects referred to in the recent meetings of the Circle, and forms a useful supplement to the address delivered by Dr. Garnett before the Circle on March 14th.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

HOLOPHANE ILLUMINATION ON THE RAILWAY.

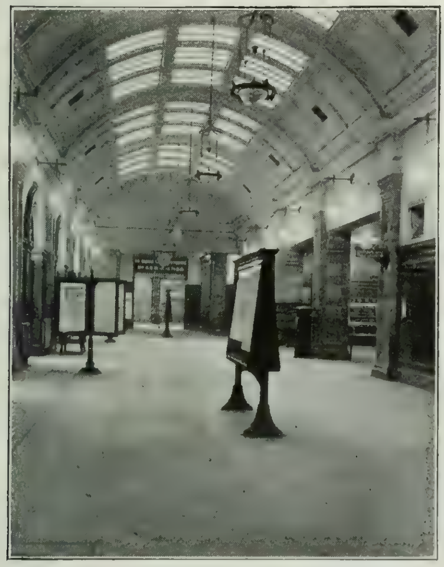

FIG. 1.—Illumination of the New Booking Hall at Euston Station with Holophane reflector bowls.

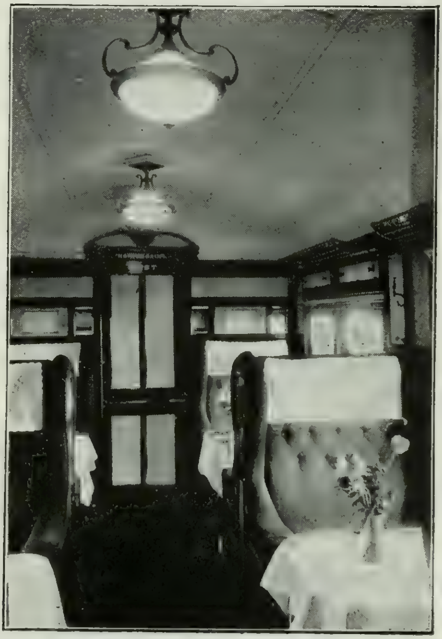

FIG. 2.—First Class Dining Coach, Great Central Railway, lighted with special Holophane glass units and "half-watt" lamps.

The lighting problems met with in railway work are distinctly varied, and we understand that Holophane units have recently been adopted by the chief railway companies for quite a number of different purposes. Apart from the utility of the standard types for lighting offices, booking halls, waiting rooms, &c., there are considerable opportunities for special contrivances in railway carriage lighting, where the methods of companies differ to a somewhat surprising degree.

Fig. 1 shows the lighting of the new booking hall at Euston station. The centre line of units consists of 200 watt lamps in 16 in. reflector bowls, while for the side lines 14 in. units with 100 watt lamps are used. The fittings, with parallel chains, are of special design.

Fig. 2, showing the arrangements in a first class dining car on the Great Central Railway, is interesting as an example of the use of 60 watt "half-watt" lamps for carriage lighting. The lamps are enclosed in special Holophane units made up of a 12 in. reflector top and corresponding "Excellite" (diffusing glass) bottom. The units are mounted direct on the ceiling. The effect is striking and the freedom from glare is doubtless a good feature.

We understand that the new industrial units, with aluminium-covered exteriors are also being widely used, particularly in some of the large munition factories. It is naturally impracticable to publish particulars of such installations at the present time, but no doubt full information will be available when the war is over.

MANUFACTURE OF BENJAMIN REFLECTORS AND FITTINGS.

WE were recently afforded an opportunity of visiting the works of Benjamin Electric, Ltd., where a great variety of reflectors for industrial lighting is being manufactured and other special war work is being done.

Probably few people realise the variety of operations involved in the production of these reflectors. The forming of the special contours requires a series of stamping processes, and the reflectors have to be annealed between each step. Then there are the subsequent operations of coating the outside and preparing the aluminium and rust-proof lacquer-protection for the interior. Some of the reflectors require at least a dozen distinct operations. Fig. 2 shows a view of the powerful press used for this work which, we understand, has been kept pretty

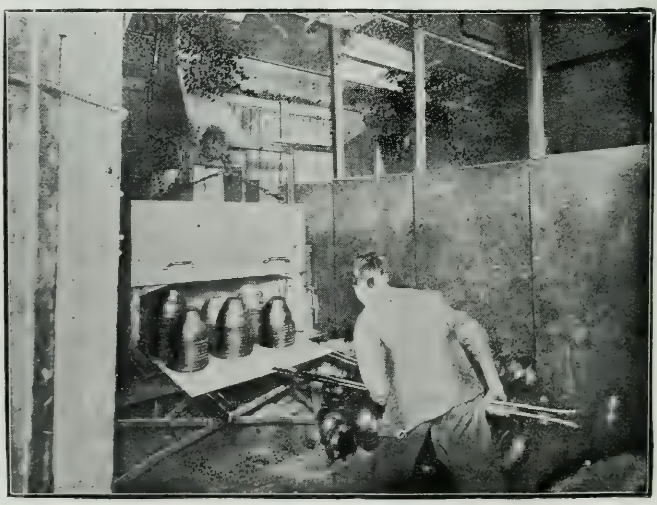

FIG. 3.—Reflectors being annealed.

continuously employed since the war commenced.

Among other operations of interest are the fitting together of Benco holders, safety-portable lamps with insulated handles and special sealed reflectors for munition work. The latter are of very solid construction and the lamp is effectually protected by a thick well-glass screwed into the reflector, so that gases and fumes in the atmosphere of the workroom cannot find their way into the interior of the unit. The reflectors are spun by hand on the lathe. The company has also been making a series of aluminium trays for the handling of acid and other materials. These must contain no joins and are also spun by hand. Seeing that some of these pans and trays are as much as four feet in diameter the work calls for considerable effort and the highest degree of skill.

There were also to be seen special reflectors made for various Government departments, one of them a new unit built up of diffusing glass, which should be very effectual in preventing glare. Another interesting item was the making of a series of large "artificial daylight" units, which, we understand, are required for special munition work in which correct colour-definition is of great importance.

A visit to these works is interesting as showing the considerable amount of extra work involved in producing metal reflectors with special contours. One can understand that the manufacture of ordinary conical shades is a much simpler matter. But the extra labour involved is compensated by the greater utility of properly designed reflectors from an illuminating standpoint, and it is satisfactory to note that the work done by the Benjamin Electric, in the field of industrial lighting during recent years, is now receiving adequate recognition.

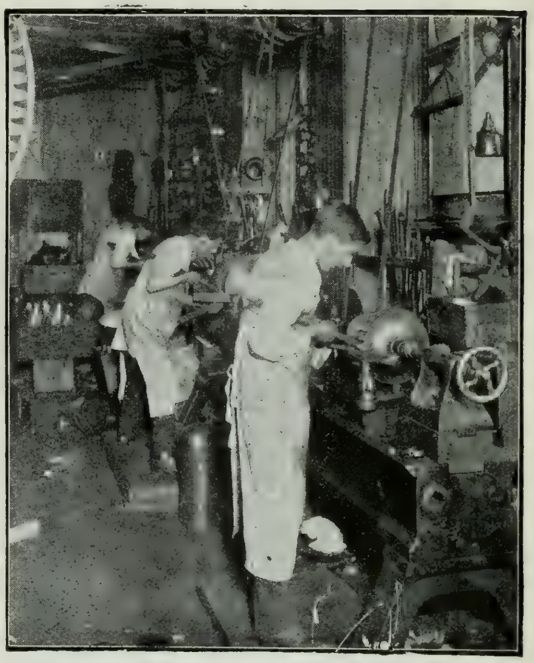

FIG. 1.—Spinning special reflectors for lighting munition works.

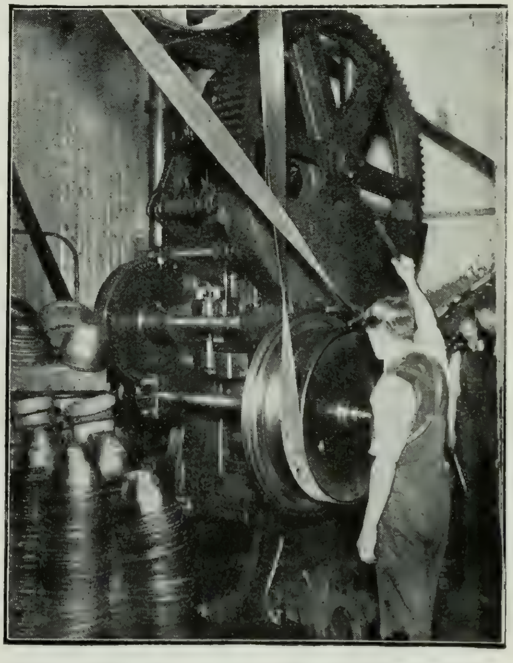

FIG. 2.—Showing the press in which the reflectors are stamped out.

REVIEW OF BOOK.

The Principles of Apprentice Training, by A. P. M. Fleming and J. G. Pearce. (Longmans Green and Co., 1916. 202 *pages.)*

In view of the recent discussions on Technical Education and Industrial Research at meetings of the Circle of Scientific, Technical and Trade Journalists, which have been summarised in this and the preceding number, the above volume is very welcome.

The book is divided into four parts, dealing respectively with The Economic Aspect, Primary Education, Vocational Selection, and Apprentice Training. The authors commence with a thoughtful analysis of the different types of industrial workers and their educational needs. In dealing with economic aspects they point out that, although the national expenditure on education cannot be regarded as excessive, much of the money spent is wasted, owing to the lack of proper supplementary training following primary education. Educational authorities and manufacturers need to get closer in touch and find common ground. In particular means should be taken to safeguard the future of educated youth and prevent the constant flow of boys into "blind alley" occupations, and more care should be exercised to determine the work for which each youth is best fitted. In the past British engineers have achieved much through inherent common sense and a kind of mechanical instinct, which almost amounts to a sixth sense. But in these days such natural advantages can no longer compete unless reinforced by scientific method and training.

A very interesting analysis is made of the system of training adopted in the schools at Gary (Indiana). Here the children are encouraged to take part in the practical work of the whole establishment—making furniture, attending to lighting motors, bells, farm work, &c., and special attention is given to vocational training.

The latter section of the book is devoted to a study of courses for apprentices, and an instructive survey is made of the methods of continuation school training in Munich—where only 8 per cent. of boys do not enter special trade schools. Stress is laid on the need for careful systematic consideration of the needs of local industries and the apportioning of the number of pupils trained to each trade. The authors also give an account of the system of instruction adopted in 1913 by the Westinghouse Electric and Manufacturing Co. in this country which, we believe, has already had a marked influence on the success of this firm during recent years.

PETROL GAS FOR COUNTRY LABORATORY GAS SUPPLY.

A leaflet on this subject, issued by County Light, Ltd. (St. Stephen's House, Westminster), describes the well-known county system of petrol air gas lighting. It is remarked that people in country districts, where there is no gas or electric supply, would often find this method of lighting very advantageous.

For laboratories the system has a special utility, being applicable both for lighting and heating, and very suitable for local bunsen burners, and luminous flat flame burners, suitable for treating glass tubing, &c. We notice among recent installations that plants are used in the Government laboratories for H.M. Ministry of Munitions, the Royal Horticultural Society's laboratories at Wisley, in Surrey, and the Clinical Laboratory at Yelverton, in Devon.

It has often been pointed out as essential that a thoroughly reliable type of plant should be used in such cases, and we notice that County Light, Ltd. undertake a guarantee to replace free of charge any part that may require renewal for five years from date of installation.

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F. NORIE-MILLER, J.P.
General Manager.

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CONCEALED LIGHTING IN A CHURCH.

We have received from the British Thomson Houston Co., Ltd., the following particulars of a novel and inexpensive lighting installation carried out by Messrs. Duncan Watson and Co., in cooperation with the B. T. H. Illuminating Eng. Dept., in St. Dunstan's Church, East Acton.

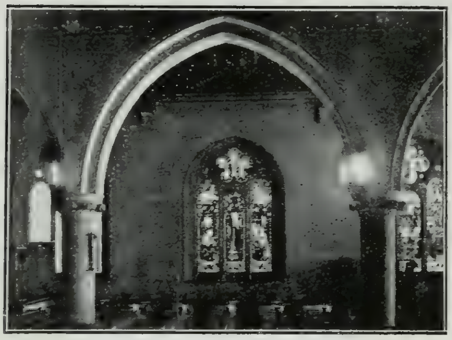


FIG. 1.—St. Dunstan's Church, East Acton. Showing arrangement of fittings where the arches spring from the pillar capitals.

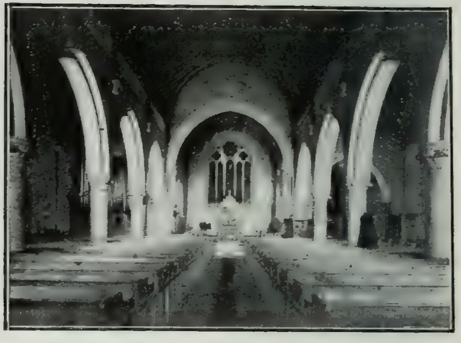


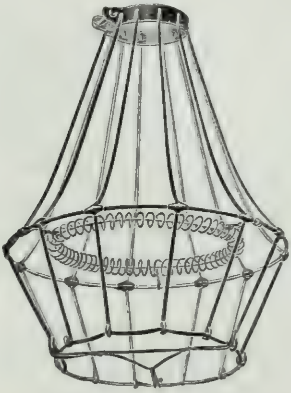
FIG. 2.—St. Dunstan's Church, East Acton. From an artificial light photograph. Note the entire absence of visible fittings.

Trough reflectors are concealed between the mouldings of the arches at the points where the latter spring from the pillar capitals. Three "Mirolux" extensive trough reflectors, each equipped with two 60-watt standard Mazda lamps are provided on the east pillars on both sides of the nave, while the lighting of the chancel is served by a pair of similar reflectors, placed above the lower capitals of the pillars supporting the main arch. Light is thrown on the altar by single trough reflectors placed within the reveals of the two side windows.

A near view of several of these units is shown in Fig. 1, while Fig. 2 gives a good idea of the effect looking down the church, the units being then out of view. The value of the illumination at the top of the pews is given as 2.5—3 foot-candles. Special units are also provided for lighting the vicar's stall and the Book on the lectern, and for the organ music.

A USEFUL LAMP GUARD.

A useful form of wire lamp guard is being supplied by the L. P. S. Electrical Co. (18, Adam Street, W.). The "Holdfast" Lamp Guard, as it is termed, is well adapted to protect lamps from shock and vibration. The wire cage terminates in a clamping collar lock which forms a permanent and rigid guard to the socket, and there is also a ring of spiral wire which supports the lower part of the bulb, and helps in preventing breakage of lamps at the neck. The whole arrangement, besides protecting the lamp, serves to keep it completely removed from contact with any possibly inflammable material in the neighbourhood, and a special trap-lock prevents the unauthorised removal of the lamp.



"Holdfast" Lamp Guard.

Another useful product issued by the L. P. S. Electrical Co. is the flexible "Duraduct" woven conduit. This is made of non-metallic material, and consists of a single wall built up of an outer surface of woven cotton, an intermediate layer of hard twisted insulating paper, and a woven cotton interior surface. The material is claimed to be fireproof, non-hydroscopic, and of high insulating qualities.

The ILLUMINATING ENGINEER

·ELECTRICITY· ·ACETYLENE·
·OIL· ·GAS·
Edited by
LEON GASTER

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EDITORIAL.

State Aid for Education and Research.

In recent discussions on technical education the need for greater support from the State has often been insisted upon. Only last month we referred to the Memorial addressed to Lord Crewe by the Professors and Staff of the Imperial College of Science, in which great importance was attached to the provision of bursaries in order to check the tendency for gifted youths to drift into blind alley occupations.

We are glad to see that this matter is dealt with in a striking Interim Report issued by the Consultative Committee on Scholarships for Higher Education. The Committee is of a very representative character, the Chairman being the Rt. Hon. Arthur Dyke Acland, whose enthusiasm for the cause of good education is well known.

The terms of reference of the Committee, which was invited to undertake its task in March, 1913, are comprehensive. They cover the whole question of the existing system of awards, whether by Local Education Authorities, by the Governing Bodies of Secondary Schools, Universities and Colleges, by the Trustees of Endowment, &c., for assisting pupils to proceed from Secondary Schools to Universities or other places of Higher Education. It is natural that at the present time the attention of the

Committee has been concentrated chiefly on the making good of deficiencies in regard to scientific and technical training, but the history of the scholarship system as a whole is reviewed, and its proper aims discussed. It is now proposed to remove inconvenient gaps in the educational ladder by providing bursaries which besides covering educational fees will leave sufficient margin to enable boys to disregard the attraction of premature occupation, Another point is the extension of research scholarships for a longer period so that gifted workers may be less apt to relinquish their experiments at the very time when they have acquired facility and expertness. Altogether a sum exceeding £300,000 is suggested for the creation and extension of scholarships of various kinds.

The Report also contains a useful introduction analysing the conditions that have retarded progress in many directions. Manufacturers, it is remarked, have shown a tendency to neglect the work of men of science ; the latter, in turn, have perhaps been too disposed to ignore the industrial development of their discoveries. The gap between practice and theory between pure and applied science, needs to be bridged. " There are three needs ; a need for pure science ; a need for applied science ; and a need for a more generally diffused interest in the principles and results of science."

This statement entirely bears out what has been said in recent issues regarding the need for co-operation between the State and the press. For the press, particularly the section of it which deals habitually with scientific and industrial matters, offers one of the most potent instruments for bringing about the required diffusion of interest in scientific methods and might become a most valuable channel for the dissemination of information amongst manufacturers and the general public.

The need for immediate action is evident, and we hope that the Report of the Consultative Committee will be promptly acted upon. It must not be supposed that while we are discussing this subject other nations are standing idle. The widespread interest in the organisation of science and industrial research is aptly illustrated by an article in the last number of the *General Electric Review*.* It is worthy of note that in 1914 the American Association for the Advancement of Science appointed a committee of one hundred to promote co-operation between the industries and universities. The recently introduced Senate Bill (4874) deals with the establishment of an engineering or mechanic arts experiment station in each State or Territory, a popular feature being the issue of regular bulletins and reports of progress at Government expense.

The proposed Federal Institute of Science and Industry in Australia we have already mentioned in these columns and we notice that in Canada a scheme for promoting scientific and industrial research is also under consideration.

Finally, we note the interesting statement that the Japanese Government has recently set aside a sum equivalent to £200,000 for the establishment of a laboratory for physical and chemical research, and that the Emperor has contributed an additional £100,000.

Britain, therefore, must guard against the supposition that the efforts she contemplates making will not be duplicated in other countries and at the present moment it is particularly vital that the Government should keep in touch with and encourage co-operation with the organisations which will doubtless be built up throughout the Colonies and Dominions.

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* Research Organisation, by W. R. Whitney, *Gen. Electric Review* (of America), July, 1916.

Lectures on Illuminating Engineering.

On page 222 in this issue will be found an announcement of the series of lectures on illuminating engineering to take place at the Pennsylvania University, on the occasion of the Tenth Annual Convention of the American Illuminating Engineering Society, to be held next September. The lectures are organised by the Society working in co-operation with the University. A very varied list of subjects has been selected and each lecture will be delivered by a specialist.

It is now six years since a similar course was arranged at the Johns Hopkins University, Baltimore, in 1910, and we are glad to see that this successful experiment is to be repeated. During the intervening period illuminating engineering has made great strides from theory to practice. At the time when the Johns Hopkins course was held the movement was concerned mainly with fundamental principles and the lectures were accordingly devoted chiefly to ideas and methods. Since then the number of workers engaged in the investigation of lighting problems has very much increased, and the experience of the past six years has served to crystallise existing knowledge. We anticipate, therefore, that the forthcoming series of lectures will form a valuable summary of the present practice in various fields of lighting.

In this country the present circumstances are naturally unfavourable to the organisation of such lectures on a large scale. The great majority of the younger men, by whom they would ordinarily be attended, are absent with the forces, and many of those whose assistance as lecturers would be desirable have other urgent claims on their services in connection with the war. It will be recalled that a start was made in 1911 by the arrangement of three simultaneous courses on illuminating engineering at various educational institutions in London, and since then special courses have from time to time been organised by members of the Society at their respective colleges. In the future, however, we hope that such lectures will be much more fully developed.

The present revival of public interest in education and science should pave the way for greater activity in the field of illuminating engineering and we have no doubt that a proper place will be assigned to this subject at the great institutions whose scientific work, already of considerable value, is destined to be extended in the near future.

This matter is one for the Illuminating Engineering Society to take up with the educational authorities at the proper time. But there are many opportunities for effort on the part of individual companies and institutions. We have quoted examples of the growing recognition of the need for fostering a belief in scientific method amongst the general public. In illuminating engineering, the case for such effort is particularly strong. Companies engaged in the supply of gas and electricity, and manufacturers concerned with the production of lamps and lighting appliances depend for their prosperity on gaining the goodwill of the commmunity. In order to extend their activities in the manner we hope and expect after the war, they should now be considering how best to train their staff to a higher degree of technical efficiency, how best to bring home to the public the value of their services, and, last, but not least, how they can combine and co-operate in order to carry out these aims.

The "Lumen" as a Basis of Comparison for Illuminants.

During recent years the practice of basing comparisons of various types of lamps and illuminating engineering calculations on the conception of flux of light, has made great progress. The Lumen, originally proposed by Professor Blondel at the International Electrical Congress at Geneva in 1896, has now become a much more familiar unit to lighting engineers, largely through the energetic popularisation of the term by our friends in the United States.

The relative merits of the "candle" and the "lumen" were debated at a meeting of the Illuminating Engineering Society in this country in 1914, corresponding members on the Continent and in the United States freely expressing their views. The general impression at that time was undoubtedly that the expression of illuminating power in terms of lumens is the more accurate and scientific method, but that the candlepower being now a well-understood and familiar term, could not be readily displaced. While, therefore, scientific men are turning towards the use of the lumen for accurate comparisons, we must in dealing with the general public, undertake an educational campaign in order to achieve the desired alteration gradually.

In comparing different types of lamps, having widely divergent polar curves of light-distribution, it has long been recognised that the plan of merely stating the light in some particular direction is quite unsatisfactory, especially now that so many different types of lamps are in use. There is much to be said for basing such comparisons on the total output of light in all directions, and once this is recognised, there seems good reason to adopt the more scientific method of specifying the flux of light.

At the last meeting of the National Electric Lamp Association in the United States the question of rating electric lamps in lumens was seriously discussed, and a recent article note in the *Electrical World* makes some comments on the subject. The remarks are substantially in accordance with the views expressed above.*

We understand that some of the manufacturers in this country are already introducing the lumen-basis in their lists. This is an enterprising progressive step. We should, however, like to suggest that for some time to come it would be advisable to state side by side both the flux of light in lumens and the consumption and candlepower values of the lamps as originally presented in catalogue literature. In this way the term "lumen" will gradually become familiar and at the same time its connection with the candlepower will be better understood.

We may also draw attention to another application of the flux of light basis of nomenclature, namely in connection with brightness-values. The specification of brightness was also discussed at the meeting of our Society in 1914 and arguments were advanced for and against the methods of expressing brightness in terms of "candlepower per square inch" and "equivalent foot-candles." It is now proposed to express the luminosity of all objects, whether self-luminous, or made visible by reflected light, in terms of lumens per unit area. With this object in view the Illuminating Engineering Society in the United States suggests as a unit the "lambert" which is the brightness of a surface emitting one lumen per square centimetre. The "lambert" is already finding its way into American literature and we give on p. 224 an explanation of this term.

L. GASTER.

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* *Elec. World*, July 1st, 1916.

THE CONDITIONS OF HEALTH OF MUNITION WORKERS.*

Since the outbreak of war the conditions of health of munition workers have been the subject of much concern. In the rush of equipping and staffing new factories many unforeseen problems arose and much valuable experience has been gained. It can hardly be doubted that this experience will have a favourable influence on the condition of workers generally after the war, and the whole question affecting, as it does, the future industrial welfare of the nation, is of great importance. In this article we are, therefore, giving a summary of some of the chief points in the publications of the Home Office and the Ministry of Munitions bearing on this point. The question of lighting, it will be recalled, was dealt with specially in the Report of the Departmental (Home Office) Committee, issued in the autumn of last year. Since that date the Committee appointed by the Ministry of Munitions on the Health of Munition Workers has issued a series of valuable bulletins, in which the whole subject is surveyed in a very practical manner. Many of the problems involved such as the conditions determining industrial fatigue, have a close relation to lighting problems and those interested in industrial illumination would do well to keep themselves informed of the progress in the study of industrial hygiene in its broader aspects.

The series of bulletins issued by the Ministry of Munitions Committee deals with the following subjects :—(1) Sunday Labour, (2) Welfare Supervision, (3) Industrial Canteens, (4) Employment of Women, (5) Hours of Work, (6) Canteen Construction and Equipment, (7) Industrial Fatigue and its causes, (8) Special Industrial Diseases, (9) Ventilation and Lighting of Munition Factories, (10) Sickness and Injury. Attention may also be directed to a Report by Mr. A. F. Stanley Kent on " An Investigation of Industrial Fatigue by Physiological Methods," issued by the Home Office in 1915.

SUNDAY LABOUR.

The problem of Sunday labour is of great importance in relation to physical and mental fatigue. " Not only must one consider the long hours of labour and the prevalent over-time, the environment of the work and the physical labour involved, but also the mental fatigue and boredom resulting from continuous attention to work." Supervision is difficult and imposes a severe strain on the foremen, constant Sunday work means high wages and bad time-keeping during the week, and there is considerable feeling that one day's rest in seven is good for body and mind.

In the case of women and young children the evils are accentuated. If employment in emergencies on Sunday cannot be avoided it is suggested that operators should not be at work on two consecutive Sundays, should have time off on Saturday, and should be employed for a portion of the day only. Even in the case of men it is recommended that Sunday work should be confined to sudden emergencies, such as the making up of occasional arrears in certain sections, and the undertaking of repairs, tending furnaces, &c., the men being given a corresponding rest during some part of the week.

EMPLOYMENT OF WOMEN.

In the case of women the problem is complicated by the fact that they have, in many cases, home duties which cannot be neglected. The question of transit facilities (also mentioned under the heading of " welfare supervision ") is most important. A day beginning at 4 or 3.30 a.m. for work at 6 a.m., followed by 14 hours in the factory and another two or two and a half hours on the journey back, may end at 10 or 10.30 p.m. "Beds are never empty and rooms are never aired, for in a badly-crowded district, the beds, like the occupants, are organised in day and night shifts. In such conditions of confusion, pressure and overcrowding, home can have no existence." Night-work, in the case of women, is particularly objectionable, as their sleep is inevitably subject to frequent interruptions during the day.

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* Bulletins Nos. 1—10 issued by the Health of Munition Workers' Committee (Ministry of Munitions), London, 1915—1916.

Welfare Supervision.

Such conditions lead one to appreciate the benefit of "welfare supervision," *i.e.*, the appointment of a staff whose sole duty it is to inquire into the welfare of employees. Among the duties of such a staff are included the registering of available houses and lodgings for employees, inquiry into means of transit and the need for fuller facilities, management of canteens, investigation of sickness, sanitation and hygiene, recreation and educational work, &c. Experience shows that the organisation of welfare supervision has a vital effect both on the health of workers and on the quality of work.

Canteen Construction and Equipment.

The question of canteen construction and equipment is discussed in two separate bulletins (Nos. 3 and 6), and practical suggestions are made for the preparation of wholesome food at a reasonable cost. In the rush of work operators are rarely in a position to prepare their own meals satisfactorily, and the time spent in getting food outside the factory during the mid-day interval is an important consideration. We are glad to note that it is laid down that "the effective cleanliness, warming (55—60 degrees), lighting and ventilation should receive careful attention and be properly and continuously maintained." Good lighting, natural and artificial, is an important factor in making the canteen attractive. Ample access of daylight is desirable, and it is suggested that the total window-area should in no case be less than one-tenth of the floor area.

Overtime and Night-work.

On the subject of hours of work reference is again made to the effect of overtime, particularly in the case of operators engaged in highly-skilled work (tool and gauge-making, tool-setters, &c.) who have frequently had to work long hours. Even at the time this report was issued 70—80 hours a week were still frequent, and in the early stages of the war as much as 90 hours was not uncommon. "The Committee are satisfied that if men are asked to work for 15 hours a day for weeks and months on end one of two results must follow: either the health of workers will break down or they will not work at high pressure." The view has been expressed that a 65-hour week, with a maximum of 80 hours in any one week was as much as men ought to be asked to work. If overtime is resorted to there should be no Sunday work.

The length of the night-shift should never exceed that of the day-shift. Night-work is regarded as uneconomical because the output during the last two or three hours of the twelve is usually low; supervision is difficult; workers find a difficulty in accommodating themselves to the practice of sleeping in the day-time, and to the unfamiliar meal times; finally conditions of lighting by night are seldom so good as in the day-time.

Industrial Fatigue.

The effects of overtime work are again mentioned in the Bulletin on Industrial Fatigue and its Causes (No. 7). In this connection the Report of Mr. Stanley Kent, mentioned above, is interesting as showing how the effect of fatigue can be demonstrated by actual tests. These include examination of the power of doing work (ergograph), muscular sense, central nervous system, including time of response to signals, acuity of vision and hearing, &c., and the circulatory system. The tests show quite clearly how a progressive fatigue occurs during the week, and how improvement follows the nightly period of rest. It is an interesting question how far such tests could be applied to determine the effect of poor lighting conditions in causing fatigue. The principle of arranging prescribed periods of work followed by appropriate intervals for relaxation goes to the root of scientific utilisation of labour. It seems reasonable to suppose that in many cases the amount of work done during a given period could be greatly increased by careful attention to this point.*

It is acutely remarked: "It is not surprising that where employers, following tradition rather than experiment, have disobeyed physiological law in the supposed interests of gain, and for a century this has been almost universal—the workers have themselves fallen very commonly into a tradition of working below their best during their spells of labour"—a slowing down that is really a kind of physiological self-protection.

The bulletin also refers to the prevalence of accidents and spoiled work, sickness, lost time, and "staleness" following fatigue.

Some interesting examples of intelligent management are given:—

> In a shell factory the men in the early hours of the war worked seven 12-hour day and seven 12-hour night-shifts during the week. More recently arrangements have been made to give every man a weekly day of rest, and the men work from 6 a.m. to 7.30 a.m., with half an hour for breakfast and an hour for dinner. Yet an increased number of shells is being produced from half the number of workers.
>
> At another large munitions factory the management insisted on a rest of 15 minutes in every hour of work. The men, being on piecework, at first objected, thinking that their output would be diminished. But when the rest was rigidly adhered to they found that the output per hour was actually increased.
>
> In a third case girls engaged in monotonous repetitive work were given a break of 15 minutes in the open air at 11 a.m. In spite of this deduction from the working hours the output per day was increased.

In conclusion it is remarked:—

> "Even during the urgent claims of war time the problem must always be to obtain the maximum output from the individual worker which is compatible with the maintenance of health. In war time the workmen will be willing as they are showing in so many directions, to forego comfort and to work nearer the margin of accumulating fatigue than in time of peace, but the country cannot afford the extravagance of paying for work done during incapacity from fatigue just because so many hours are spent upon it, or the further extravagance of urging armies of workmen towards relative incapacity by neglect of physiological law."

SICKNESS AND INJURY.

Bulletins Nos. 8 and 10 deal respectively with "Special Industrial Diseases" and "Sickness and Injury." Among the former are included various dangers incidental to munition work, such as lead-poisoning and the effects of fulminate of mercury, tetryl, tri-nitro-toluol, &c.

Among causes of sickness and injury are mentioned excessively long hours of work, particularly at night, cramped postures and constrained attitudes during work, muscular strain, machinery accidents, poor ventilation, imperfect lighting whether by day or night (which conduces to eyestrain and headaches), noxious gases and vapours, dust produced in various processes, &c.

The careful supervision of the sick-rate, and the provision of proper methods of detecting early indications of sickness and securing prompt medical attention for same, are insisted upon. The study of the sickness rate is a most important guide to defective conditions. A case is mentioned of a large munitions works in which the sickness rate increased progressively from 2.4 to over 4 per cent., while the accident-rate also rose. Among men on overtime work the sickness rate was in one case 5.5 as compared with 3.7 among those on double shifts. Overtime and night-work seem to be common explanations of a rising sickness rate.

The data for accidents and first-aid supply confirmatory evidence. Thus in one works during the autumn of 1914, when the hours of work were from 8 a.m. to 5.45 p.m. an average of 100 first-aid dressings were done each month per 1,000 employed; in 1915 for the same period of the year, when the hours of work were from 8 a.m. to 8 p.m., the average rose to 292, and at night, when the hours of work were from 8 p.m. to

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* An incident at the front is of great interest in this connection. Two officers, for a wager, competed in making equal lengths of a certain trench, each with an equal squad of men. One set his men to work as they pleased, but as hard as possible. The other divided his men into three sets to work in rotation, each digging their hardest for five minutes and then resting for ten, till their spell of labour came again. The latter team won easily.

8 a.m., to 508. This increase is attributed to: (1) longer hours, (2) more thorough organisation of first-aid treatment, and (3) the fact that a greater proportion of the workers are engaged at night employed on machines as compared with daytime.

The above data are of particular interest to readers of this journal, in view of the stress laid on the extra difficulties, both as regards fatigue and accidents, of persistent night work. It is highly probable that this is due in part to the fact of the conditions of illumination being less satisfactory than those prevailing in the day-time, and it will be observed that this fact is specifically mentioned by the Committee in Bulletin No. 5 on Hours of Work (p. 8). Defective lighting is also mentioned in Bulletin No. 10 (Sickness and Injury) as conducive to eyestrain and headache. Many of the other causes of sickness are, no doubt, also connected with lighting defects. Thus machinery accidents are increased by poor lighting, as the machine is less carefully tended and therefore apt to break down, and employees may endanger their life through inability to see machinery clearly. Insufficient light on the work or glare no doubt adds to the strain of work, accentuating fatigue, while badly-placed lamps giving inconvenient shadows lead to workers adopting cramped positions.

VENTILATION AND LIGHTING.

In Bulletin No. 9 on Ventilation and Lighting of Munition Factories, ventilation, heating, and lighting are discussed in some detail. It is pointed out that the desirable atmosphere in workshops should be :—

(*a*) Cool rather than hot.

(*b*) Dry rather than damp.

(*c*) Diverse in its temperature in different parts and at different times rather than uniform and monotonous and (which is intimately connected with this diversity)

(*d*) Moving rather than still.

In dealing with Lighting the Committee have naturally taken note of the Recommendations in the Report of the Departmental Committee on this subject, and comment on this subject as follows :—

IV.—LIGHTING.

12. This question has been treated with thoroughness and care in the Report of the Departmental Committee on Lighting in Factories and Workshops,* which has recently been published, and little more is necessary than to refer briefly to the main conclusions of that report.

The essentials of good lighting are there summarised as :—

(*a*) Adequacy.

(*b*) A reasonable degree of constancy and uniformity of illumination over the necessary area of work.

(*c*) The placing or shading of lamps so that light from them does not fall directly on the eyes of an operator when engaged on his work or when looking horizontally across the workroom.

(*d*) The placing of lights so as to avoid the casting of extraneous shadows on the work.

13. Natural lighting is to be preferred to artificial lighting on grounds of health as well as of economy. Where it can be arranged, roof lighting is generally to be preferred to lateral lighting. In a good system of roof lighting the illumination is very uniform. In modern factories where lateral lighting is employed a large part of the walls are devoted to windows, but it is evident that there is a limit to the width of the room, beyond which the illumination falls below what is adequate; what this width is will depend partly on the nature of the work to be done in the shop and partly on the extent to which the light is impeded by outside obstacles such as neighbouring buildings or inside obstacles such as machinery.

14. The effect of light-coloured walls and white ceilings on the general brightness of the room and in affording an effective background to dark objects should not be overlooked. In some cases the natural lighting may be improved by deflecting vertical light into the room by means of reflectors or prismatic glass, or by whitening the surface of an external wall or building which obstructs the light. The position of permanent working points should be so adjusted in relation to the windows and to internal obstructions of whatever kind as to secure, so far as practicable, adequate daylight for each.

15. The necessity for the regular cleaning of windows on the inner and outer surfaces cannot be too much insisted on. Not only do dirty windows prevent a large proportion of daylight from entering the shop, but the daylight period of work is considerably shortened and needless expenditure on artificial lighting incurred in consequence. At the present time the anti-air raid darkening regulations have much intensified this loss of natural light. In the construction of shops care should be taken to render the out-

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* First Report of Departmental Committee on Lighting in Factories and Workshops, 1915 (Cd. 8,000).

sides of windows easily accessible for cleaning. In many existing shops access is so difficult as to make cleaning almost impossible.

16. The question of artificial lighting is of special importance at the present time, when night work is general, and when women and boys are employed in large numbers. Bad lighting affects output unfavourably, not only by making good and rapid work more difficult but by causing headaches and other effects of eye-strain; the difficulties of supervision, which are always considerable, are further increased if the general lighting of the workshops is insufficient.

A factory may be instanced where in one shop the ceiling was uniformly whitened and illuminated by arc lights which were shaded from the workers. The shop was illuminated by an agreeable diffuse light which cast no shadows. To produce the best effect the entire top surface can be covered with sheets of metal and enamelled white. Such a method of lighting may prove to be more costly in upkeep, but it has compensatory advantages in promoting the health of the workers and thus may prove to be economical in the long run. In an adjoining shop the lighting was carried out by electric lamps each suitably shaded to throw light down on the lathe, and not on the eyes of the workers. In still another shop of the same factory fish-tail gas burners were in use, the lighting by such means being very poor and quite unshaded. Owing to the impoverished illuminating power of gas its use without incandescent mantles is to be condemned. Excellent lighting is obtained by the use of incandescent mantles and gas under pressure. The lamps in lofty shops can be placed high up so that they shed a diffuse light without directly throwing a glare into the workers' eyes.

17. Attention should be paid to the lighting of the passages and immediate surroundings of the factory as well as to that of the workshops themselves. In the Report of the Departmental Committee, standards of lighting for factories are suggested, and though the figures given are the minima considered necessary, they may, at any rate, prove of assistance in suggesting the relative amount of light necessary in different parts of the factory.

ENGINEERING EDUCATION AND RESEARCH.

A valuable Report on this subject was recently prepared for the Council for Organising British Engineering Industry by Mr. A. P. M. Fleming (*Superintendent of Insulation and Transformer Depts., Brit. Westinghouse Elec. and Manufacturing Co.*), Prof. C. J. Maxwell Garnett, M.A. (*Principal of the School of Technology and Dean of the Faculty of Technology in the University of Manchester*), and Prof. Miles Walker, M.A., M.I.E.E. (*Professor of Elec. Eng. in the School of Technology and in the University of Manchester*).

A distinction is drawn between the training of manual workers and thinkers in industry. Workers, after passing through the public elementary school, should proceed to a junior technical school, where they can be specially educated with a view to their industrial employment (somewhat on the lines of the methods of Osborne school for the navy). At the age of fifteen they should enter work as apprentices, and their course of training should include lectures and instruction, besides works experience. Specially gifted youths should be selected for higher training at universities.

Much greater facilities are also needed for university courses for engineers intended to occupy higher positions in industry. Additional scholarships are required and the arrangements at different training centres and towns should be made more uniform. At present a boy's chance of winning a scholarship depends greatly on the local educational endowment, in fact on the town in which he happens to live.

Suggestions are also made for the better organisation and application of research, for which a central institution is needed.

Apart from its practical value to industry, research acts as a valuable educational element. "The personal influence of the man doing original work in his subject inspires belief in it and awakens enthusiasm and gains disciples. It is by associating students throughout their university careers with such men that their own latent originality is best developed."

STATE AID FOR RESEARCH AND TECHNICAL EDUCATION.

THE Interim Report just issued by the Consultative Committee on Scholarships for Higher Education (Board of Education Cd. 8291) makes a number of suggestions for stimulating the pursuit of scientific knowledge and industrial research.

During the last forty years scientific and industrial research has admittedly not made the progress in this country which modern conditions demand. Common sense, energy, voluntary effort, spontaneous enterprise were responsible for the great industrial progress of Britain in the first part of the last century. But after the war of 1870 a new era, based on the methodical application of scientific knowledge and method began, and here we have temporarily fallen behind. The development and application of scientific effort has been less complete and the relation between industry and science has not been satisfactory. Business men have considered scientific workers unpractical; men of science have not secured from industry the necessary encouragement and incentive to effort. This gap between requires to be bridged.

Since the outbreak of war an important step in this direction was taken in the appointment of the Committee of the Privy Council on Industrial Research. Efforts are also being made to ascertain and remedy defects in the present system of education. The Report contains an analysis of the functions of Elementary, Lower Secondary and Junior Technical Education, a special reference being made to the need for further development of the Trade Continuation Schools. There is a great gap between in the educational development of children after leaving school, and able youths drift into blind alley occupations, merely in order to earn immediate wages. To correct this tendency it is proposed to award to gifted boys scholarships and bursaries sufficient to cover the fees of education in important branches of trade and also to remove the temptation of seeking immediately remunerative but ultimately undesirable employment.

In addition to this additional scholarships at Technical Institutions and Universities are suggested, and it is mentioned that the sum at present allotted to in this way is only about one-sixth of that provided in Germany.

Simultaneous with the fostering of education, opportunities for the employment of those so educated should be developed; otherwise there is a danger of the situation which at one time arose in Germany, where there existed a surplus of educated workers unable to find suitable employment and forming a discontented element in the population.

It is therefore necessary to proceed with caution. But at present the lack of sufficient scientifically trained men in this country is so manifest that there is ample scope for encouragement of such education. It is therefore proposed that the following sums should be set aside for this purpose:—

	£
For strengthening the higher parts of selected Secondary Schools	100,000
For maintenance grants to Scholars to enable them to receive Higher Secondary Education from 16 to 18 or 19 ..	90,000
For Government Scholarships from Secondary Schools to the Universities, &c., in Scientific and Technical subjects ..	67,000
(For the additional cost of such Scholarships if held at Oxford and Cambridge)	10,000
Grants in aid of Local Authorities for Scholarships to Universities from Secondary Schools ..	25,000
For Scholarships from Senior Technical Schools, &c., to the Universities	27,000
For prolongation of Scholarships at the Universities for training in Research	20,000
	£339,500

COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

STANDING COMMITTEE ON ENGINEERING.

The Standing Committee on Engineering appointed by the Advisory Council for Scientific and Industrial Research held its first meeting on Wednesday, 7th June. The Committee has been so constituted as to represent both the scientific and the industrial sides of engineering, and includes the following members nominated by the Professional Associations :—

Institution of Civil Engineers, Sir Maurice Fitzmaurice, C.M.G. ; *Institution of Electrical Engineers,* Mr. J. S. Highfield ; *Institution of Mechanical Engineers,* Dr. Dugald Clerk, F.R.S. ; *Institution of Naval Architects,* Sir Archibald Denny, Bt. ; *N.E. Coast Institution of Engineers and Shipbuilders,* Mr. Herbert Rowell ; *Manchester Association of Engineers,* Mr. Alfred Saxon ; *Institution of Engineers and Shipbuilders in Scotland,* Mr. James Brown ; and the following members directly by the Advisory Council :—

Mr. F. R. Davenport, Mr. Alfred Herbert, Professor Bertram Hopkinson, F.R.S., Mr. C. H. Merz, Mr. V. L. Raven, Mr. A. A. Remington, Mr. G. Gerald Stoney, F.R.S., Mr. Douglas Vickers, Professor Miles Walker.

The Advisory Council have appointed Sir Maurice Fitzmaurice, C.M.G., to be chairman.

The Committee was welcomed by Sir William M'Cormick, Chairman of the Advisory Council, and Dr. H. F. Heath, Administrative Secretary of the Council. Sir A. Selby-Bigge, Secretary to the Committee of the Privy Council for Scientific and Industrial Research, also attended and emphasised the importance attached by the Government to the need for greatly increased activity in research in connection with industry. In Sir Maurice Fitzmaurice's opening statement as Chairman of the Standing Committee several important aspects of the Government Scheme as issued in July, 1915, were referred to, and attention was directed in particular to the necessity for securing that British industries shall get as large a share as possible of the full value of the results of any successful researches and shall retain at least the initial advantages derived from them. He felt in this connection that the Committee would be in a position to advise the Government organisation for Research as to the means of securing that their operations should yield the maximum benefits to the trade and industry of the Empire. Applications for aid must be dealt with on as broad lines as possible, without red-tape and with a constant regard to the ultimate object of the Government Scheme which is to help the industrial community of the Empire in the contest with the common trade enemy. It would be of great value that applicants for assistance to researches should make it clear at the outset whether results if obtained should be considered as of a confidential nature, as in arranging our experimental work we must avoid conditions calculated to help foreign competitors. Much time and money had been spent upon research in the works of individual firms whose aggregate expenditure for the purpose far exceeded the sums at the disposal of the Committee of Council, and from the industrial side such work by firms appealed to him as the most hopeful arrangement. But the Government had made a decided step forward by showing their interest in industrial research, and though he expected much more from the scheme, the gain would be great if the only result were the training of research workers. Too much must, however, not be expected from research and experimental work in themselves, for these alone would not win back the industries which should never have left us or even retain those we still possessed. Though it was not for the Standing Committee to deal with such questions, individual and combined efforts were needed to secure that the products of this country find their way to those who need them at home and abroad, and to see that what is wanted is supplied by our industries. Sir Maurice Fitzmaurice hoped that it would be possible to co-operate with our fellow-countrymen beyond the seas in carrying out many useful investigations.

ILLUMINATING ENGINEERING LECTURE COURSE AT PHILADELPHIA.

Under the joint auspices of the Illuminating Engineering Society (U.S.A.) and the University of Pennsylvania.

It will be recalled that in 1910 a lecture course was arranged by the American Illuminating Engineering Society in co-operation with the Johns Hopkins University, at Baltimore, U.S.A. This course was devoted mainly to the *science* of illumination. It is now proposed to hold a series of lectures in Philadelphia, as mentioned above, which will deal chiefly with the *art* of illumination. The course will include about twenty lectures by specialists, and will be supplemented by an exhibition, at the University of Pennsylvania, of the latest developments in lamps, lighting appliances, photometers, &c. Visits will also be arranged to various manufacturing works, laboratories, lighting companies and notable installations.

The following is the preliminary list of subjects for lectures :—

SUBJECTS AND LECTURERS.

(A)—*General*—

(1) Illumination Units and Calculations, A. S. McAllister.
(2) Modern Photometry : Clayton H. Sharp.
(3) The Principles of Interior Illumination (two lectures) : Committee, J. R. Cravath, Chairman.
(4) The Principles of Exterior Illumination : Louis Bell.
(5) Colour in Lighting : M. Luckiesh.
(6) Architectural and Decorative Aspects of Lighting : Guy Lowell.
(7) Recent Developments in Electric Lighting Appliances : G. H. Stickney.
(8) Recent Developments in Gas Lighting Appliances : R. ff. Pierce.
(9) Modern Lighting Accessories : W. F. Little.

(B)—*Lectures on Interior Illumination*—

(10) The Lighting of Factories, Mills and Workshops : C. E. Clewell.
(11) The Lighting of Offices, Stores and Shop-windows : N. Macbeth.
(12) The Lighting of Schools, Auditoriums and Libraries : F. A. Vaughn.
(13) The Lighting of Churches : E. G. Perrot.
(14) The Lighting of the Home : W. H. Jordon.
(15) Railway Car Lighting : G. E. Hulse.

(C)—*Lectures on Exterior Illumination*—

(16) Street Lighting (two lectures : (a) P. S. Millar ; (b) C. F. Lacombe.
(17) The Lighting of Yards, Docks, and Outside Works : J. L. Minick.
(18) Headlights, Searchlights and Projectors : E. J. Edwards.
(19) Sign Lighting : L. G. Shepard.
(20) Exhibition and Pageant Lighting : W. D'A. Ryan.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

Tenth Annual Convention.

We are informed that the following list of subjects has been approved by the Papers Committee for the coming Tenth Annual Convention of the American Illuminating Engineering Society, to be held in Philadelphia next September :—

Coloured Glasses for Illuminating Engineering, by Dr. H. P. Gage.

Lighting of Cleveland Museum of Art, by Dr. E. P. Hyde.

Illuminating Engineering Photographs, by B. H. Norris.

Some New Phenomena of Persistence of Vision, by Dr. H. E. Ives.

The Effects of Brightness and Contrast on Vision, by Dr. P. G. Nutting.

Apparent Brightness and its Properties, by Dr. L. T. Troland.

Integrating Spheres, by F. A. Benford.

Street Lighting, by Ward Harrison.

Gas and Electric Lighting in the Home, by C. H. French and C. J. Van Gieson.

Optic Projection as a Problem in Illumination, by J. A. Orange.

Forced Life Testing of Incandescent Lamps, by L. J. Lewinson.

THE EFFICIENCY OF PROJECTORS AND REFLECTORS.

By Haydn T. Harrison, M.I.E.E.

(Abstract of Paper read before the Liverpool Engineering Society, February 23rd, 1916.)

An interesting paper on the above subject was read before the Liverpool Engineering Society on February 23rd, Professor E. W. Marchant in the chair. In his introductory remarks, Lieut. Harrison, R.N., explained that he had lately conducted a series of researches on search-lights in connection with his work in the Navy, but was not at liberty to refer to them in detail.

The effective range of search-lights is chiefly a matter of obtaining the maximum candle-power in the direction of emission, *i.e.*, of diminishing the angular spread of the beam to the smallest figure. In ordinary circumstances if one increases the current supplied to the arc, the candle-power is increased, but at the same time the size of the crater becomes greater. Consequently, although the total candle-power is improved, the dispersion is also increased and there is no great gain in "maximum candle-power." With a 150 amp. arc, producing a crater 23 mm. in diam., a 90 cm. diam. mirror, with 45 cm. focus, may be used. The intensification produced by the mirror would thus be :—

$$\frac{1-\text{Cos } 45^\circ}{1-\text{Cos } 2^\circ} = 500 \text{ times.}$$

Thus an arc giving ordinarily 50,000 candle-power, would yield a beam-power of 50,000×500, or 25,000,000 candles.

In order to produce a substantial advance in this figure it is necessary to produce a source of light giving equal or greater candle-power from a crater-area less than that of the present arc ; this has been accomplished by cooling the outer surface of the carbon, which enables the diameter of the core to be reduced to nearly one-third for the same current. Another step has been the embodying in the core of ingredients of the type used in flame carbons.

By these means a lamp giving double the light, and a beam-divergence of only 1° can be obtained, and the intensification factor becomes :—

$$\frac{1-\text{Cos } 45^\circ}{1-\text{Cos } 1^\circ} = 1952 \text{ times.}$$

Moreover, as the candle-power produced is also approximately doubled, the useful illuminating power of the combination is increased approximately *eight* times.

Experiments have also been made with gas-filled incandescent lamps with the object of securing maximum concentration of light. The more concentrated arrangement and greater intrinsic brilliancy of modern lamps is favourable to high efficiency in the reflector. For example, by using a 6-volt 108-watt lamp (having a very compact filament), it is possible to produce a reflector giving seven times the multiplying power obtainable when using a 100-volt lamp under the same conditions. When one compares the total luminous flux reflected by most reflectors with the lumens produced by the lamp used with them, one sees that there is great scope for improvement, even in up-to-date modern reflectors.

For many purposes a very concentrated beam is not necessary, but for special purposes it is highly desirable. In his work in the Navy the author has succeeded in producing reflectors which, with a dispersion of six degrees, produce a candle-power about 1,000 times that of the original lamp.

Referring to street-lighting problems, the author laid stress on the importance of accurate control of light by reflectors. With the modern high candle-power incandescent lamps of comparatively small weight, there seems no reason why lamps of several thousand candle-power should not be mounted as high as 16 ft. above the ground. This would be effectual both as regards direction of light and diminution of glare.

It is to be noted, however, that glare does not depend only on intrinsic brilliancy but on contrast. A motor-car head-light is considerably more glaring than an arc lamp of the same candle-power in an opalescent globe, because in the latter case the brightness gradually diminishes from the centre to the periphery, while in the former we pass suddenly from brightness to darkness.

THE "LAMBERT": A NEW UNIT OF BRIGHTNESS.

Readers of American literature on illuminating engineering have no doubt perceived the appearance of a new unit, recently adopted in that country for the specification of brightness value, the "lambert," and it occurred to us to give the definition of this term. A lambert is the brightness of a surface which emits one lumen per square centimetre of radiating surface. The term can be applied both to surfaces which produce light (such as the flame of a candle, an incandescent mantle, or a globe-screened electric lamp) or to surfaces which receive light and become luminous by reflection. Thus a perfectly reflecting and diffusing surface, following Lambert's cosine law exactly, which received one lumen per square centimetre, would have a brightness of "one lambert." In practice there are no such surfaces. Therefore, when one speaks of an illuminated area as having a brightness of so many lamberts one means that it has a brightness equivalent to that of an ideal reflecting surface receiving one lumen per square centimetre. The ordinary gas flame has a brightness of about one lambert; this is about 7 per cent. less than a surface-brightness of one foot-candle.

SELENIUM CONTROL OF TORPEDOES.

In the *Electric World* some time ago* the suggestion was made that torpedoes might be automatically directed to follow and sink warships carrying search-lights, by means of selenium cells. Mr. B. F. Meissner has constructed an "electric dog," *i.e.*, a small vessel on rollers whose mechanism is controlled by a selenium cell and which follows the beam of a small hand-lamp carried about the room. It is suggested that in night operations a selenium-controlled torpedo might react in a similar manner to the beam of a distant search-light, so that any ship using a search-light to detect submarines would automatically bring about its own destruction.

* May 1st, 1915.

SYNTHESIS OF COLOURS BY THE THREE-COLOUR METHOD.

It is well known that there are available instruments for accurately analysing, according to an arbitrary scale, the colour of different glasses and fabrics, and in Germany an instrument was brought out some time before the war which, by the rotation of one of a pair of Nicol prisms, between which is placed a piece of quartz, enables any desired tint to be reproduced.

A simple apparatus for the same object has been produced in the United States by Mr. M. R. Pevear.* It employs a combination of three 40-watt lamps in front of which are placed respectively sheets of red, green and blue glass. The combined light from the three lamps illuminates a white surface, and each lamp is controlled by a separate rheostat. By this adjustment a wide range of complex colours can be produced and any desired tint exactly matched. The same principle has long been employed for the production of colour-effects in stage lighting, and in a compact form the apparatus would no doubt be useful in trades concerned with coloured fabrics.

* *Elec. World*, Feb. 13th, 1915.

THE PROPER METHODS OF COMPARING GAS AND ELECTRIC LAMPS.

COMPARISON ON A LUMEN BASIS.

An article by G C. Shadwell in the American Gaslight Journal for Jan. 31st 1916, points out some of the sources of uncertainty in the comparisons often made between gas and electric light as commonly made. Such comparisons are inevitably much affected by local circumstances. The conditions which decide a consumer to use gas in preference to electricity or vice versa often include many factors which cannot conveniently be introduced into a pure comparison of cost.

But it is at least desirable that cost-comparisons should be conducted on lamps of about the same intensity and should be free from avoidable ambiguities. For example, both in the case of gas and electric lamps, the candle-power is often assumed in some particular direction, without considering whether the comparison will hold good for the light at other angles. The author therefore suggests that comparisons should be made on the basis of the total output in lumen-hours during a specified period. It is also proposed that the quality of gas used should be specified and that gas lamps should be rated on the basis of " lumens per B.Th.U. per hour."

In order to illustrate his method the author makes a comparison of two lamps, one described in the Proceedings of the Am. Gas Institute for 1912 (p. 322), the other an electric incandescent lamp of about the same candle-power described in " Engineering Data " of the General Electric Co. (U.S.A.) April, 1915. The comparison works out as follows :—

The small upright burner gas lamp was used with water-gas (0·717 s.g.) giving 632 B.Th.U's. per cubic ft. Other data available are :—

Pressure.	Consumption.	M.S.C.P.	Lumens.	Lumens.	
				per B.Th.U. per hr.	per cub. ft. per hr.
2·5 in.	1·21 cub. ft. per hr.	27·0	338·8	0·443	296·6

The electric lamp (multiple tungsten inct.) is described as follows :—

Volts.	Watts.	M.S.Cp.	M.S.C.P. per watt.	Lumens.	Lumens. per watt.
105—125	40	30·4	0·76	381	9·52

Assuming the cost of gas to be 1 dollar (4s. 2d.) per 100 cub. ft., and the electric energy to cost 0,1 dollars (approx. 5d.) per unit, the costs for the two lamps will be :—

Electric lamp, cost per lumen per hour=

$$\frac{0\cdot1\times1}{9\cdot52\times1000}=$$

·0000105 dollars (=0·0002d. approx.)

Gas lamp, cost per lumen per cub. ft per hr.=

$$\frac{1}{296\cdot6\times1000}=$$

·0000034 dollars(=·00007d. approx.)

The ratio of costs is therefore approx. 3 : 1.

Naturally the assumptions made would not necessarily apply in this country, (where the costs of gas and electricity are different), and apart from this it should only be regarded as applying to the units in question and not to gas and electric lighting generally.

LIGHT-REFLECTING VALUES OF WHITE AND COLOURED PAINTS.

A PAPER on this subject by H. A. Gardner recently appeared in the *Journal of the Franklin Institute* (Jan., 1916). The difficulty in estimating the reflecting power of coloured materials lies, not only in the colour-difficulties inevitably involved in a comparison with white light, but also in the complexities introduced by surfaces which are not matt, but more or less glossy. Such surfaces appear to have a different reflecting value according to the angles from which they are viewed, and the best method would appear to be to take note of the light reflected in all directions.

In order to accomplish this result the author makes use of the following arrangement. A disc 3¼ in. diameter, coated with the paint in question, is placed at the centre of an integrating sphere (Ulbricht globe) and illuminated by the light of a concentrated filament lamp shining through an opening in the top of the sphere. The light fell on the disc at an angle of 45 degrees. Practically all reflected light is received by the walls of the sphere and is measured by means of an observation window in the usual way.

For the purpose of standardisation such surfaces are compared with an arbitrary standard white material. For this purpose a block of magnesium carbonate is used, the comparison being effected by substituting this for the surface to be tested within the globe. The coefficient of reflection of this material was found by Nutting, Jones and Elliott to be 88 per cent.*

Using this figure as a basis the author finds the following values for the reflecting power of various pigments used for colouring walls :—

Colour.	*Coeff. of reflection.* per cent.
White Standard (Mag. carbonate)	**88**
Light cream	66
Light pink	60
Light Yellow	58
Light blue	55
Light greenish yellow	54
Light buff	52
Light green	42
Light terra-cotta	41
Medium terra-cotta	39
Light greenish blue	36
Medium blue	32
Warm green	19
Medium green	14
Red	12
Blue, dark	12
Green	11

The value of this determination is increased by the fact of the author giving, side by side with the above figures, an inset on which actual coloured samples of the materials tested are attached.

ENGINEERING STANDARDS COMMITTEE.

At its main meeting on Friday, July 14th, 1916, the Engineering Standards Committee passed two Resolutions placing on record their deep sense of the loss sustained by them, and by the Engineering Industry generally, in the tragic deaths of Sir Frederick Donaldson and Mr. Leslie S. Robertson.

Sir Frederick Donaldson rendered extremely valuable services to the cause of Engineering Standardisation, especially in his capacity as Chairman of the Sectional Committee on Screw Threads and Limit Gauges.

In the death of Mr. Leslie S. Robertson the Engineering Standards Committee has lost an able and energetic secretary, and the Committee recognise that the movement owes a very deep debt to the ability he brought to bear upon many difficult problems, which arose in the course of its growth.

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* Trans. Ill. Eng. Soc. U.S.A., Vol. 9, No. 7, 1914.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

A Report presented by the Committee on Progress (Mr. F. E. Cady, *Chairman*, Mr. T. J. Litle, Mr. L. B. Marks, Mr. T. W. Rolph), at the Ninth Annual Convention of the Illuminating Engineering Society, held in Washington, September 20th to 23rd, 1915; slightly abbreviated.

(*Continued from Vol. VIX., March* 1916, *p.* 106.)

Street Lighting.

Display Lighting.—A general survey of the progress in the lighting of streets shows that there has been a decided increase in ornamental lighting[92] for advertising purposes, so-called "White Way" lighting. Among the cities where such installations have been made during the past year may be mentioned Portland, Ore.,[93] where a system has been placed on one of the business streets consisting of crossed structural steel arches bridging the crossings and supported on concrete columns. Each of these arches is outlined by 192 incandescent lamps placed on the under side. "White Way" lighting has also been installed in Newark,[94] N.J., using lamps of 500 candlepower; in Louisville,[95] Ky.; in Lowell,[96] Mass., where 234 magnetite 6.6-ampere arc lamps have been used, placed 14.5 ft. (3.20 m.) above the sidewalk and with a maximum distance between units of 120 ft. (00.00 m.) and a minimum of 50 ft. (15.24 m.), lamps being located as far as possible on alternate sides of the streets; in Union,[97] N.J., where 40 gas-filled 500-watt tungsten lamps were used; in Paterson,[98] N.J.; in Sioux Falls,[99] S.D., where 156 luminous arc 6.6-ampere lamps have been placed six to the black in a staggered arrangement; in Sandusky,[100] O., where 14 city blocks are involved and 380 gas-filled tungsten lamps of 250 candlepower each are mounted on two-light standards approximately 50 ft. apart; furthermore a complete lighting system for the city is being installed consisting of 920-60 candlepower and 100 candlepower lamps of the same type; in Cleveland, where 600 gas-filled 20-ampere tungsten lamps are mounted on standards with a special type of glassware consisting of a refractor to give the desired distribution of illumination, and an enclosing globe with roughened surface which is designed to have a pleasing appearance without materially changing the distribution due to the refractor; in Charleston, W. Va.,[101] where 62 ornamental luminous 4-ampere arc lamps have been installed; at Malone, N.Y.,[102] where 400-candlepower gas-filled tungsten lamps mounted on ornamental posts were installed; at St. Cloud, Minn.,[103] where the number of arc lamps was increased to 100 and changed to the luminous or magnetite type.

There is[104] a tendency away from the use of five-lamp standards for a "White Way" lighting inasmuch as they are too prominent in the daytime. Preference to-day inclines toward a single or at most a double-light unit with a comparatively high candlepower lamp. The introduction of the gas-filled tungsten street series unit has, in general, resulted in increasing[105] the candlepower used and not in decreasing the wattage. In addition to the improvement in efficiency the new construction has made possible an extension in the range of candlepowers available thus giving greater

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[91] *N. E. L. A. Bul.*, May, 1915, p. 340.
Elec. World, Mar. 27, 1915, p. 805.

[92] *Municipal Jour.*, June 24, 1915, p. 886.

[93] *Pop. Mech.*, July, 1915, p. 101.

[94] *Elec. Rev. and W. E.*, Nov. 14, 1914, p. 954.

[95] *Elec. Rev. and W. E.*, Nov. 14, 1914, p. 954.

[96] *Elec. Rev. and W. E.*, June 5, 1915, p. 1039.

[97] *Elec. World*, June 26, 1915, p. 1697.

[98] *Municipal Jour.*, May 27, 1915, p. 740.

[99] *Light. Jour.* (U.S.), May 1915, p. 98.

[100] *Elec. Rev. and W. E.*, May 22, 1915, p. 963.

[101] *Municipal Jour.*, July 22, 1915, p. 114.

[102] *Elec. Rev. and W. E.*, July 31, 1915, p. 180.

[103] *Municipal Jour.*, May 27, 1915, p. 729.

[104] *Elec. World*, May 22, 1915, p. 1328.

[105] *N. E. L. A. Bul.*, Mar., 1915, p. 171.

flexibility to this type of lighting. The feasibility of replacing arc lamps with incandescents for street lighting has been agitated ever since the introduction of incandescent units of sufficient intensity to produce comparable results. The question has been re-opened since[106] the introduction of the high candlepower tungsten lamps. Numerous tests have been made and reports given on the relative merits of the two types of illuminants and on the relative cost of operation. But there are so many factors entering into the problem that it seems increasingly difficult to draw even general conclusions.

[After this there follows an account of the lighting arrangements adopted in various American cities (with reference Nos. 107—121), which restrictions of space compel us to omit. Ed.]

Investigations.—The investigation of street lighting being carried on under the joint auspices of committees of the National Electric Light Association and the Association of Edison Illuminating Companies and which was started last year is[122] still uncompleted. To properly interpret results already obtained requires a complete knowledge of the conditions and no attempt will be made to summarise them in this report. Another investigation of the factors connected with effective illumination of streets has been directed toward a study of the effect of glare on visual acuity. The method[123] of test consisted in making observations of a special visual acuity test chart first with the street lamps off and then under ordinary lighting conditions. Among the conclusions reached were that merely surrounding a brilliant source of light by a diffusing globe does not materially diminish blinding effects. Mounting heights less than 20 ft. (6.09 m.) should be avoided if possible and heights less than 15 ft. should never be employed. When the height is relatively low the candlepower between the angles of 65° and 90° from the vertical should also be relatively low. So far as avoidance of glare is concerned there is no object in increasing the height beyond 50 ft. (15.24 m.).

Other Exterior Illumination.

The continued improvement in illuminants is reflected in the spread of outdoor-lighting of all kinds and the use of light more than ever before for a variety of purposes. Thus a real estate dealer arranges to have a new sub-division highly illuminated[124] and rapidly sells his lots to customers who have come out to view them at night. Improvements in distance lighting and control[125] have made feasible the employment of gas in places where its use had previously been considered impossible. A big extension is to be noted in the use of light for exterior advertising purposes.

Flood-lighting.—One of the most striking illustrations of the modern "flood-lighting" method of illuminating the exterior of buildings is to be found in the lighting of the Woolworth building[126] in New York City, which was disclosed to public view at the beginning of the year. It has been said that more light is provided for the illumination of the tower than is usually employed in lighting a city of 30,000 inhabitants. 600 automobile projector units fitted with 250-watt, gas-filled tungsten lamps are used to throw light on the structure from the thirtieth to the fifty-eighth storey. These projectors are arranged so that some throw their light upward and the rest throw their light downward. Thus there is one continuous diffusion of light over the whole surface. The lamps throwing light downward are carefully screened so as not to be directly visible from the street. The most novel point of the installation, however, is at the sixtieth storey called the "crow's-nest" or "lantern." It has been enclosed with diffusing glass and within are placed twenty-four 1,000-watt lamps. An automobile dimmer connected with these lamps continuously alters their intensity in an irregular cycle. Thus at one instant the glass surface of the lantern shows a deep red glow no brighter than the adjacent gilded structure, and again it flares up to a bright white light many times this brightness and visible for miles.

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[106] *Jour. f. Gas.*, Aug. 1, 1915, p. 777.
Elec. World, June 19, 1915, p. 1594.
Ibid., July 10, 1915, p. 109.
Elek. u. Masch., Feb. 7, 1915, p. 73.
Elek. Zeit., June 3, 1915, p. 269.

[122] Trans. *I. E. S.*, 9, 1914, p. 536.
Report of Committee on St. Light. *N. E. L. A.*, June, 1915. See also Trans. *A. I. E. E.*, July, 1915, p. 1379

[123] *Elec. Rev. and W. E.*, Mar. 6, 1915, p. 439.

[124] *Elec. Rev. and W. E.*, May 8, 1915, p. 856.

[125] *Gas Age*, July 1, 1915, p. 5.

[126] *Elec. Rev. and W.E.*, June 5, 1915, p. 1048.

The flood-lighting idea has been much extended in[127] the illumination of advertising signs on billboards, water tanks, roofs of buildings, side walls and elsewhere. In such cases the effect is accomplished by directing a beam of light against the sign from some near-by convenient location, and a new lighting unit of high intensity utilising a parabolic reflector has been recently developed for this special purpose.

Lighting of Sports.—The lighting of courts for tennis and other sports has proved so satisfactory that the idea is being tried out in a number of different ways. A playground in a city park has been illuminated so that[128] its various amusements are available at night as well as by day. Five 750-watt, gas-filled tungsten lamps are used to light the football field while 1,000-watt units are used to illuminate the swings and gymnasium apparatus. These units are placed 20 ft. (6.09 m.) above the ground on goose-neck boulevard posts. A test was made at the Indiana State Fair grounds recently of[129] a system of illumination, in order to try out the practicability of automobile racing at night. The result was a complete success. Lights of the type used in contracting and railroad work for emergency operations at night, were placed at intervals about the track. Each light was supplied from its own cylinder of dissolved acetylene. In another case[130] an outdoor skating rink used for the sport of curling has been lighted by tungsten lamps installed on two lines of stray wires, extending the length of the rink, and about 35 ft. (10.66 m.) apart. Extra illumination is furnished at the ends over the goals. The lamps hang about 15 ft. above the surface of the ice.

A sign of progress[131] is to be noted in the installation of a lighting system on the celebrated wall which surrounds the block in Salt Lake City enclosing the famous Tabernacle and Temple. The wall is approximately 12 ft. (3.65 m.) high and will be lighted by high power lamps located every 50 ft. (15.24 m.).

Because of the scarcity of kerosene there has been an extension of gas and electric lighting in Germany,[132] alcohol and acetylene being adopted in the country districts.

Interior Illumination.

The trend in interior lighting continues to be in the direction of protecting the eyes from excessive brightness.

Hotel Lighting.—A recently finished, and[133] what is claimed to be largest hotel in Europe, has been fitted throughout with the semi-indirect system of illumination. The lighting has been so arranged that corridor lights are independent of those in adjacent bedrooms. In the dome of the rotunda court a novel plan has been adopted of introducing opal bulls-eyes with a lamp behind each, into the risers which support the glazing of the dome. Around the dome cornice is a ring of lamps which are concealed from view at the floor level but throw a considerable volume of light upward into the dome. Some 6,000 lamps are used in this hotel. In England[134] the use of high pressure gas is being extended to factory lighting.

Municipal Buildings.—While a private enterprise is quick to see and adopt improvements in lighting sources and methods, the municipally controlled institution has in the past exhibited a decided inertia in this respect. A start has been made in Boston[135] to remedy this and the replacement of old types of lamps of low efficiency has already brought about a marked saving to the city. The change has been so satisfactory that one of the city engineers is to devote his entire time during this year to improving the lighting of buildings in the school, police and fire departments.

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[127] *Elec. Merchandise*, Dec., 1915, p. 306. See also *Cent. Sta.*, May, 1915, p. 346.

[128] *Elec. World*, May 22, 1915, p. 1328.

[129] *Sci. Amer.*, June 12, 1915, p. 587.

[130] *Elec. Rev. and W.E.*, Feb. 13,1915.,p.311.

[131] *Elec. Merchandise*, Apr., 1915, p. 82.

[132] *Pop. Mech.*, May, 1915, p. 651.

[133] *Elec. Times*, June 24, 1915, p. 531.

[134] *Jour. of Gas Lt.*, June 1, 1915, p. 506.

[135] *Elec. World*, May 22, 1915, p. 1327.

Office Buildings.—Heavy glass partitions which are translucent, substantial, sun-proof, and fire-proof, are being introduced, as a[136] means of distributing sunlight through large office buildings, without lessening the privacy of the various offices. These partitions are built of clear glass units, 2 in. (50.80 cm.) thick, and either 6 or 8 in. square, which are reduced to translucency by impressed designs.

Hospitals.—That the educational work of the Society on the subject of colour and glare is bearing fruit, is seen in the use of green and buff for the colour of the walls in a large Western[137] hospital. White had always been used, but it was found, on trial, that the discomfort coming from the necessity of eye-adaptation on the part of surgeons looking up from their work, and seeing only white-clothed assistants and white walls was largely eliminated with the use of other colours. The effect on patients has also been beneficial. In another large city hospital a rather unique use of the mercury vapour lamp is found in its employment[138] for examination of X-ray skyographs.

Street Railway Cars.—A growing recognition of the importance of proper lighting in every sphere of activity is illustrated in the[139] recent extensive tests conducted by a large municipal railway. A full sized template car was built and tested when equipped with direct, semi-indirect, and totally indirect systems of lighting. The general effect and appearance of each system under test were judged by comparison with present methods of car lighting for similar service. The effect of the light on the eyes was particularly noted by a large number of observers. The system finally adopted consists of a single row of 56-watt, bowl-frosted tungsten lamps placed symmetrically down the centre line and equipped with opal glass reflectors. The above lamps were supplemented by six 10-watt, all-frosted round bulb tungsten emergency lamps. One big unit was placed on each end-bulkhead of the car to bring up the illumination at these points. In the car as finally equipped the illumination averaged 5.94 foot-candles, at normal and 3.85 at 85 per cent. voltage, the energy consumption was 1.44 watts per square foot, effective lumens per watt 4·14 and the utilised efficiency 50.6 per cent.

Another street railway company is emphasising[140] the "Safety First" principle by providing a light so placed as to directly illuminate the step of the street car. A practical application of signal lights has been adopted by[141] some of the theatres of Vienna. On the back of each seat is a small electric lamp which illuminates the seat number. As long as the seat is turned up, as it usually is when not occupied, the light is burning, but is shut off when the seat is turned down. By this means the use of ushers has been materially decreased.

Clock Tower.—A novel use for the method of indirect lighting is to be found in the illumination of clock dials in the new Boston Custom House.[142] Behind each dial is a chamber with white walls illuminated by a number of lamps. Numerals of the dial are in the form of slots set in concrete and the lights in each chamber are so arranged that no unreflected light passes through the slot. The effect is to make each numeral appear as if cut out from a piece of uniformly lighted paper.

An application of the "flood-lighting" idea was made[143] recently at one of the automobile shows where a machine was brilliantly illuminated by lights in two ornamental troughs hung by chains about 8 ft. from the floor, and 9 ft. (2.74 m.) in front of the car.

The art-glass dome is ordinarily associated only with the lighting of dining-rooms, but it has been added[144] to the long list of illuminants used to produce an attractive show window illumination.

(*To be continued*)

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[136] *Pop. Mech.*, June, 1915, p. 818.

[137] *Pop. Elec. and Mod. Mech.*, Dec., 1914, p. 644.

[138] *Elec. World*, June 5, 1915, p. 1475.

[139] TRANS. I. E. S., 1915, p. 227.

[140] *Elec. Ry. Jour.*, Jan. 30, 1915, p. 247.

[141] *Pop. Mech.*, Apr., 1915, p. 568.

[142] *Pop Mech*, July, 1915, p. 75.

[143] *Elec. World*, May 15, 1915, p. 1255.

[144] *Elec. World*, May 22, 1915, p. 1315.

TOPICAL AND INDUSTRIAL SECTION.

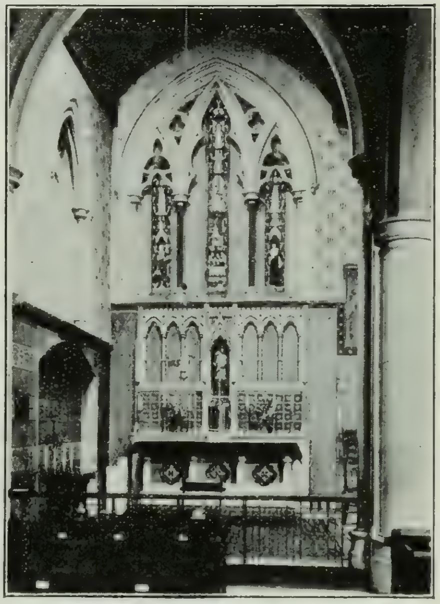
[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

CONCEALED LIGHTING IN A CHURCH.

The illustration shows an interesting method of lighting employed in the Sacristy of St. Mary's Church, Croydon. The illumination is derived from three Holophane reflectors of special type, which carry spiral tungsten filament lamps, the whole being arranged to give a highly concentrated downward light. The units are mounted directly behind the arch at the exceptional height of 20 ft. This has the effect of making the altar stand out prominently, and the restful effect is well adapted to church lighting. The illumination on the altar was found to be 2 to 2·5 foot-candles. A similar arrangement is used for illuminating the choir and organ, but in this case the illumination value is higher, namely, 5 to 6 foot-candles.

The whole of this Church is lighted throughout with Holophane units. Five-light fittings, with 60 watt lamps and Holophane extensive type reflectors are used to illuminate the main body and single pendants with 100 watt lamps and intensive type reflectors are used for the side aisles. The illumination on the reading plane in these sections is stated to be 2 to 2·5 foot-candles.



Effect of concealed lighting with tungsten lamps and Holophane reflectors in the Sacristy of St. Mary's Church, Croydon.

For the above information and photograph (the latter having been taken by artificial light), we are indebted to Holophane, Ltd.

GAS LIGHTING IN A PHILADELPHIA CATHEDRAL.

A PAPER describing the lighting of the Cathedral of SS. Peter and Paul in Philadelphia was recently read before the Illuminating Engineering Society (U.S.A.) by Mr. James D. Lee, of the United Gas Improvement Co. (of that city), to whom we are indebted for the accompanying two photographs of the installation. We observe that these photographs appeared in an article in the December issue of *New Business*. An account of the installation is also given in the *Gas Age* for April 1st, from which the following particulars are taken.

The illustrations suggest that the installation is of an interesting example of what can be done by modern gas units of a decorative type. The production of artistic gas fittings, particularly those of the semi-indirect type, has made considerable headway in this country (it will be recalled that some good illustrations of semi-indirect lighting were shown at the National Gas Exhibition in 1913), and while these aspects of lighting are inevitably overshadowed by more important work during the war, we look for continued development in the future.

It will be seen that the chief element in this particular installation is the production of soft diffused illumination effects, such as are naturally suited to a cathedral. The fittings are of the semi-indirect type, which is effective for illuminating the surroundings and showing up the architectural features of the building. The units are so arranged that the congregation have a clear and unobstructed view of the main altar; and the reflected light from the arches, besides giving a pleasing impression, is helpful in diffusing the general illumination. The complete installation comprises twelve fixtures (six with fifteen mantles and six with twelve mantles per fixture), conforming in design to the period of the architecture of the church. The fixtures are of massive construction, but so designed as to give no impression of clumsiness and to harmonise with the building. Each fixture weighs about 200 lbs. The piping is quite inconspicuous, and the control of the lamps is effected by a chain pull and pilot.

The lighting is so arranged as to be serviceable for all occasions requiring artificial light. Thus at the early morning services the two fixtures on either side of the altar, the two at the back of the transept, and the two forward in the nave are used. On Sunday all fixtures are lighted from 4.30 a.m. until 12.30 noon on dark days. The full lighting is also used for all evening services. Two fixtures are found to suffice to enable people to find their way about in comfort.

Experience shows that with burners of the horizontal type employed 2.75 cub. ft. of gas per mantle are required, and approx. 315 lumens per cub. ft. of gas per hour obtained.

A very careful study of the conditions of brightness giving the best effect was made, and the following particulars are given by Mr. R. F. Pierce, of the Welsbach Co.:—

A. 0·00185 c.p. per sq. in., arches of chapels.
B. 0·00185 c.p. per sq. in., domes of chapels.
C. 0·306 c.p. per sq. in., ceiling of nave.
D. 0·301 c.p. per sq. in., brightness of dish.
E. 0·256 ft.-candles, transept, first front pew.
  0·338 ft.-candles, transept, midway to fixture, directly underneath.
F. 1·74 ft.-candles, directly beneath unit No. 5 (15 mantles).
G. 1·37 ft.-candles.
H. 1·04 ft.-candles.
I. 1·04 ft.-candles.
J. 0·00088 c.p. per sq. in., brightness of altar.
K. 0·000095 c.p. per sq. in., brightness of darkly painted walls.
L. 0·0000 c.p. per sq. in., brightness of main altar.
M. (1) 0·22, transept middle aisle, front pew.
  (2) 0·26 transept middle aisle, midway.
N. 0·58 ft.-candles, nave middle aisle, between units 4 and 9.
O. 0·38 ft.-candles, transept middle aisle, front pilaster.
P. 0·58 ft.-candles, nave middle aisle, between units 3 and 10.
Q. 0·58 ft.-candles, nave middle aisle, between units 2 and 11.
R. 0·475 ft.-candles, nave middle aisle, under organ loft.

It is remarked that the soft nature of the lighting conditions enables a lower illumination to suffice than if the lighting were of a glaring character. The arrangements have evidently been the subject of careful forethought and scientific design, and this doubtless accounts for the success of the installation.

A GAS DISPLAY IN JANESVILLE (Wis. U.S.A.).

WE notice, in *New Business*, an account of the gas display at a recent "Made in Janesville Week" at the city of that name.

Great efforts were made to render the display attractive, both as regards the use of gas for heating and cooking, and for illumination. In lighting the various stalls semi-indirect methods played a conspicuous part.

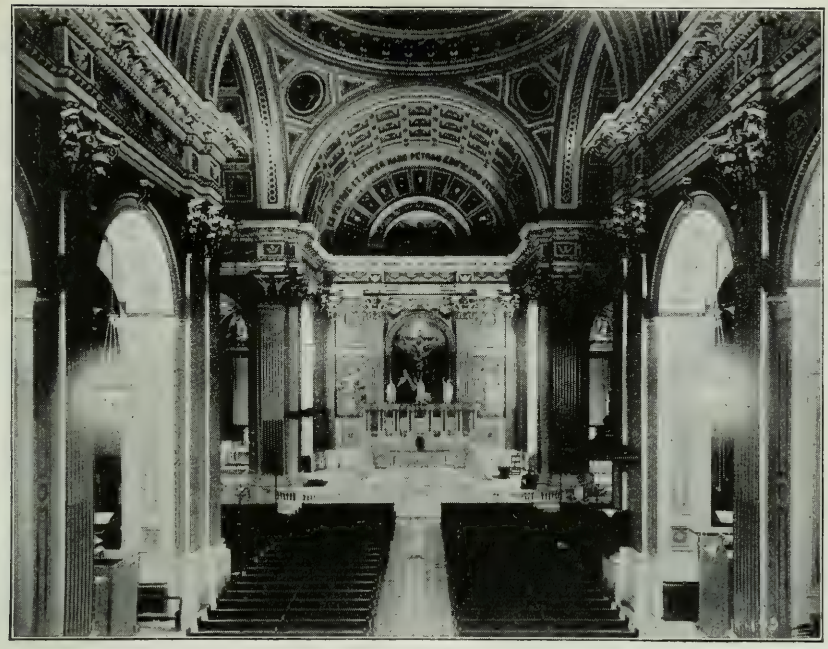


FIG. 1.—Night photograph, showing semi-indirect gas lighting in the Cathedral of SS. Peter and Paul, Philadelphia ; looking towards the main altar.

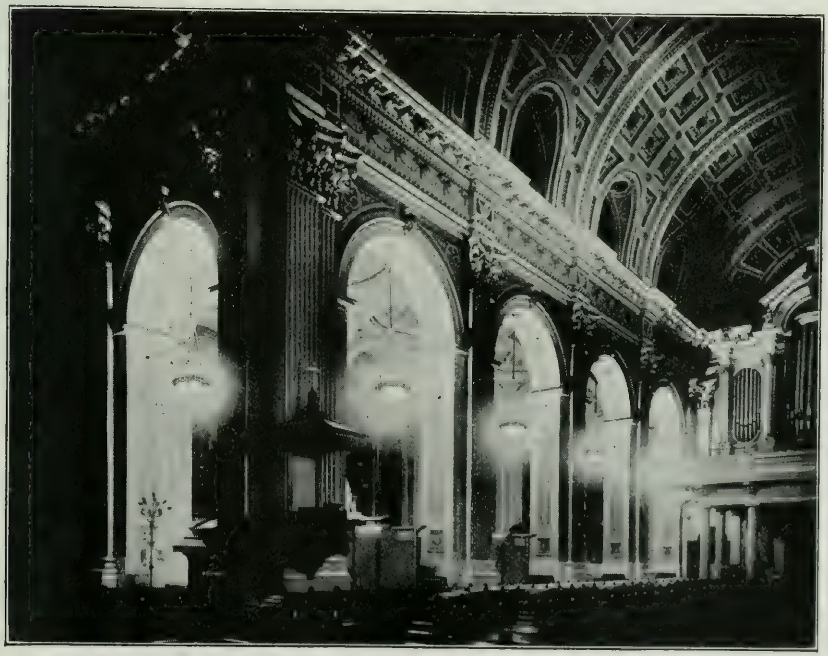


FIG. 2.—Another view showing the effective side-lighting of the Cathedral.

PETROL AIR GAS FOR COUNTRY LABORATORIES.

A note on this subject appeared in our last issue, and we have now received particulars of another system, the "Willett Light," which we understand is specially adapted to the lighting and heating of country laboratories.

The Willett generator is driven by weights, the rate of revolution is low, and all the essential parts are constructed of brass or copper—all items which make for simplicity in operation and durability of the plant. In common with the best modern plants, the Willett system is stated to be entirely automatic, the quality of gas being maintained constant irrespective of the number of lights turned on. Another feature is that gas is produced from ordinary No. 1 motor-car spirit, easily obtainable in the most remote districts.

While readily applicable to lighting country houses, farms, churches, &c, dairies, cow-houses and out-buildings of various kinds, the application of the system to laboratories where heating as well as lighting is commonly required, is of special interest at the present time. While for ordinary lighting purposes petrol of 0·720 specific gravity (ordinary motor car spirit) is advised, and a mixture of 1½—2 per cent. of petrol with 98½—98 per cent. of air used, a somewhat richer mixture is desirable for laboratory purposes. In this case spirit of 0·680 specific gravity is preferred.

In this way a gas is produced which can be used as readily as coal gas for bunsen burners, blow-pipes, muffle furnaces, &c. In the case of country laboratories, having no gas-supply available, this is obviously an important point which will have a decided influence in determining the form of lighting to be adopted. We are informed that among the laboratories that have used this system include: The Royal Naval Airship Station Experimental Laboratory, the laboratories of H.M. Ministry of Munitions, Messrs. Kynoch-Arklow, Ltd., Nobel's Explosive Co., Distington Iron Works, the Ammonia Soda Co., Ltd., &c.

The system may be seen in operation and all additional particulars obtained at W. Willett's showrooms at Sloane Square. Booklets descriptive of the system will be sent post free on request.

BOARD OF TRADE ANNOUNCEMENT.

Coal Supplies.

A circular issued by the Board of Trade on the subject of Coal Supplies draws attention to the following Regulation made by Order in Council under the Defence of the Realm Acts on June 27th :—

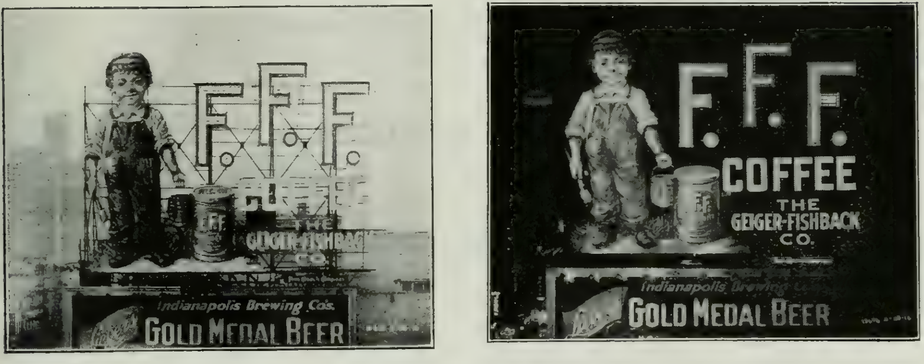
> "2D. It shall be lawful for the Admiralty or Army Council or the Minister of Munitions, or any person authorised by them to act in their behalf, after consultation with the Board of Trade, to give directions as to the priority to be given in the execution of orders or contracts for the supply of coal or coke, with a view to securing precedence for orders or contracts in accordance with their national importance, and the owner, agent or manager of any mine or any other person affected by the directions who fails to comply with any directions so given, and any person who in any certificate or document given or issued for the purpose of securing priority for any order or contract in pursuance of such directions makes any false statement or false representation, shall be guilty of an offence against these Regulations."

In addition, Section (2) of the Defence of the Realm (Amendment) No. 2 Act, 1915, provides that :—

> "where the fulfilment by any person of any contract is interfered with by the necessity on the part of himself or any other person of complying with any requirement, regulation, or restriction of the Admiralty or the Army Council under the Defence of the Realm Consolidation Act, 1914, or this Act, or any regulations made thereunder, that necessity is a good defence to any action or proceedings taken against that person in respect of the non-fulfilment of the contract so far as it is due to that interference."

While the existence of these Orders is pointed out, it is stated that the work of the District Coal and Coke Supplies Committees has hitherto been carried on by general consent, and it is hoped that few cases will arise in which it is necessary to use the powers conferred.

"FLOOD-LIGHTING" IN THE UNITED STATES.



View by day. View by night.

Night and day views of a large 35 × 70 ft. sign in Indianapolis (U.S.A.), showing effect of artificial "flood-lighting."

The First National Bank, Cleveland (U.S.A.), lighted by 24 X-ray projectors from a building across the street.

In a recent number of THE ILLUMINATING ENGINEER* we reproduced a view of the Woolworth Building Tower in New York, which is illuminated by concealed projector lamps. The accompanying views shows some other examples of this method of lighting, kindly sent to us by the National X-Ray Co. of Chicago, which show the striking effects obtainable. It is stated that by the aid of these specially designed focusing reflectors, and with lamps of appropriate concentrated filaments, an equivalent candle-power of as much as 67,000 can be obtained by an expenditure of only 250 watts.

One of the illustrations shows the application of this system of "flood-lighting" to the frontage of an imposing Cleveland bank. The other views illustrate its utility for sign lighting. It has often been pointed out in these columns that there are great possibilities in concealed lighting for exhibition and spectacular purposes, and that such methods, which comply with the fundamental principle of "light on the object, not in the eye," are often much more effective than the practice, so common in the past, of outlining signs and buildings with clear bulb electric incandescent lamps.

In the present circumstances, spectacular lighting is naturally inapplicable in this country. But it is still well worth while to study its possibilities with a view to development after the termination of the war. Apart from its utility for signs and for advertising purposes, it is also conceivable that, carefully applied, it would have a genuine use for displaying the architectural features of buildings. One point, however, requires to be remembered. In most of these American cities the atmosphere is presumably comparatively free from smoke, and the surfaces of buildings do not so readily assume the sooty appearance common in London and other large European cities. It remains to be seen, therefore, how far the comparatively low-reflecting value of the surfaces of many of our buildings would interfere with the application of concealed lighting.

It is also possible that, even in the present circumstances, concentrating units of this kind would have useful applications for military work. We understand that the British Thomson-Houston Co., Ltd., are sole agents for the development of the X-Ray appliances in this country.

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* April 1916, p. 145.

REVIEWS OF BOOKS.

Occupations, from the Social, Hygienic and Medical Points of View. By Sir Thomas Oliver, M.A., M.D., LL.D. (Cambridge University Press, Public Health Series. 1916. 110 *pp.*)

SIR THOMAS OLIVER is an acknowledged expert on this subject, which is of absorbing interest.

In the introduction to this volume he traces the gradual evolution in industry following the introduction of machinery. The old cottage handicrafts have disappeared. Modern conditions of work are more strenuous and exacting and less healthy. The monotony of factory life tends to dwarf individuality and develops a special form of mental depression which leads to a longing for excitement and recreation unknown in past centuries. The investigation and gradual removal of these defects offer one of the most important fields for study open at the present time.

The book deals in turn with various factors prejudicial to health, each point being illustrated by striking examples. Readers cannot fail to be impressed by the evidence supporting many of the contentions of experts on industrial hygiene, and to appreciate that these are not matters of conjecture, but the result of actual observation of facts.

The initial chapters deal with the air breathed in town and factory. It is now recognised that pulmonary diseases are closely related to the presence of infected dust. Street-dust frequently contains tubercle bacilli, and a case is mentioned in which tarring the roads adjacent to a factory was followed by a diminution in the average sick rate from 30 to 12 per cent. In special trades where the dust from glass, stone, and iron is prevalent phthisis is common. In the Rand Mines the problem is particularly grave (rock-drillers, it is said, rarely survive more than 6—7 years occupation in this work), but matters have been improved as a result of precautions introduced by the S African Government on the advice of the author.

Sir Thos. Oliver also gives some interesting tables, illustrating the death- and sickness-rates in various occupations. Agriculture proves to be one of the healthiest employments. The comparative mortality in file-making, a very unhealthy occupation, is three times as great, and the relatively high rates in glass making, lead working, cutlery, and other trades gives some idea of the constant waste of life and health in industry that has to be made good.

Yet, it is interesting to notice, the unoccupied do not escape—indeed their mortality greatly exceeds that of the workers in average trades, chiefly owing to the prevalence among them of respiratory and nervous diseases. This seems to suggest—what is no doubt the case—that idleness is on the whole prejudicial to health.

A striking instance of the physical deterioration caused by dangerous trades is afforded by the sulphur mines of Sicily

In this district, it is stated, the Italian Government finds it almost impossible to obtain conscripts.

The author also dwells on the effects of rush and "speeding up" in causing accidents and inducing fatigue. He reproduces Haegler's curve, showing the course of recuperation during the night's rest, and the progressive increase of fatigue during the working week. A rest of one day in seven is fully justified on physiological grounds. Actual instances are mentioned in which persistent overtime led to a diminution in output, while shorter spells of work, with more frequent intervals for recuperation, brought about improvement, both in quality and quantity of the output.

A special reference is made to the effect of unsatisfactory illumination in causing accidents and increasing the fatigue experienced in doing skilful work. Poor lighting conditions, the author remarks, pay neither the employer nor the employed. Special importance is attached to the provision of adequate illumination for dark materials, the avoidance of glare, the proper lighting of flights of stairs, and the use of appropriate shades and reflectors.

A chapter is given up to the care of the health of workers, and some account is given of the social welfare work now being widely organised.

The book is one that may be read with profit and interest by all concerned with industrial problems, and is very opportune at the present moment when so many factories are working at high pressure.

Trade as a Science *By Ernest J. P. Benn, with a Preface by Lord Burnham.* (*Jarrold and Sons.* 1916. 184 *pp.*)

LORD BURNHAM, in his introductory preface to this work, acutely points out that while to-day all the world is talking of trade, "the only person who is silent about it is the tradesman." This presumably is due to the rooted suspicion of solidarity of action and "disinclination to discuss," on which Mr. Benn lays so much stress. Yet it is undeniable that the tradesman is the person most directly interested. Mr. Benn makes it quite clear that while suitable assistance from the Government in many directions might be beneficial, it is to the efforts of traders themselves, and particularly their concerted efforts in the form of Trade Associations, that we must look for the solution of the present difficulties.

Mr. Benn puts his case with moderation, and deals with the various problems in a practical way. He dwells on the exceptional financial conditions which may be expected to prevail after the termination of war, and points out that the payment of interest on accumulated debt must be met mainly by producing and selling more goods. In the past the British manufacturer has lost ground by conservative methods of manufacture, and lack of enterprise in seeking and utilising new markets, but he has always had one great asset—his reputation for honesty and the "square deal."

Most of the faults can be traced to extreme individualism—disinclination to compare experience with others in the same trade, and apathy in neglecting to form powerful Trade Associations of the kind existing abroad. Such associations as exist in this country are not truly representative, are poorly supported, and are not empowered to deal with really vital problems of real concern to the industry they represent. Mr. Benn advocates the establishments of associations on an adequate scale, able to collect information about foreign markets, investigate problems in manufacture, freight, etc., and deal directly with labour in their respective industry. Powerful bodies of this kind, however, would arouse suspicion of being "trusts," and it is therefore suggested that they should be subject to some form of Government control under a Ministry of Commerce. Government support would also be helpful in overcoming the initial prejudices of many manufacturers. The need for a Minister of Commerce has been frequently urged of late, but its functions and constitution are outlined by Mr. Benn in greater detail than by many others who have discussed the matter.

In addition to the Secretary of State for Commerce, an Advisory Council, and the Parliamentary and Permanent Secretaries, Mr. Benn suggests that there should be six under-secretaries, dealing respectively with Export, Industrial and Scientific Research, Commercial Education, Statistics and Finance, Labour, Exhibitions, and Advertising. Finally, he suggests the appointment of three hundred Trade Secretaries, whose salaries are paid half by the Government and half by the Associations they represent.

The book contains many novel and interesting suggestions, and we commend it to the notice of our readers.

Discovery, or the Spirit and Service of Science. By Prof. R. A. Gregory. (Macmillan and Co., London, 1916.)

PUBLIC indifference to the value of science has often been ascribed to defects in our present educational system. But a secondary explanation is no doubt to be found in the high degree of specialisation in modern scientific work, rendering it difficult for the layman to follow; and in a certain lack of skilful popular exponents, willing and able to interpret these things to a popular audience in the manner of Huxley, Tyndall and other great figures of the past century. A work like Prof. Gregory's, interesting to experts and yet capable of being read with pleasure by those who have no claim to scientific attainments, therefore fulfils a most useful function at the present time.

In the introduction the author disposes of the idea that a man of science is "a callous necromancer who has cut himself off from communion with his fellows," and protests against the conclusion, sometimes drawn by people horrified by the present world-conflict, that science is necessarily connected with materialistic domination. On the contrary the greatest men of science learned humility from their peculiarly exacting vocation and by direct contact with nature, and have done much of their best work without thought of reward.

The examples of scientific work selected by the author are taken from many fields and are designed to show the futility of the popular disposition to encourage only those varieties of work which lead to immediate practical rewards. On the contrary many of the greatest discoveries, which have had the most profound influence on social life, had no apparent applications when they were made. Faraday's work on electromagnetism, Newton's discovery of the composition of white light, the experiments of Berzelius on the rare metal thorium, are only a few links in the long chain of researches which paved the way for the practical exploitation of science to-day. Of equally far-reaching importance to mankind have been the great researches in the fields of bacteriology, anti-septic treatment of wounds, anti-toxins, &c., some of which were undertaken by the discoverers at great personal risk.

At the present time a great deal is being said on the subject of industrial research; "to the engineer the fascination of experimental research lies, as Captain Cuttle would observe, 'in the application thereof.'" But it is to be hoped that the present movement in favour of research will not be conducted entirely in the hope of immediate material gain and that we shall escape the mental attitude which led the President of the tribunal of Revolutionists to condemn to death the great chemist Lavoisier in 1793 with the cold comment, "La Republique n'a pas besoin de savants."

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F. NORIE-MILLER, J.P.
General Manager.

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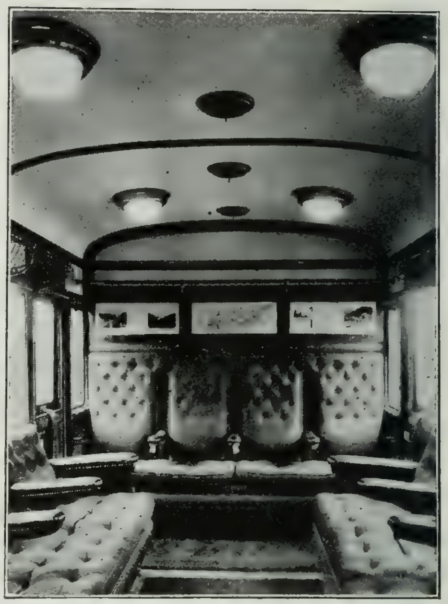
RAILWAY CARRIAGE LIGHTING.

In our last issue (p. 205) we reproduced an example of railway carriage lighting on the Great Central Railway by special Holophane units. The photograph now shown illustrates another installation, namely, a First Class Coach on the London and South Western Railway (Electrical Extension), which is lighted by six Holophane 10 in. Stiletto Bowls, carrying 40 watt lamps. Here again the method of mounting the units direct on the ceiling has been adopted, giving a pleasing illumination effect with the lights out of the direct range of sight and absence of glare. The minimum value of the illumination at the reading level along the seats is given as 2·5 ft.-candles.

There is no doubt that in the most modern coaches on up to date railways the conditions of illumination represent a great advance on those prevailing a few years ago, though in some cases progress is naturally limited by the present lighting restrictions.



Lighting of 1st class carriage (L. & S. W. Ry. electrical extension) with 40-watt lamps and Holophane 10 in. stiletto bowls.

PROGRESS OF ELECTRICAL ENGINEERING FIRMS.

It will be recalled that the Annual Report of the British Westinghouse Electrical and Manufacturing Co., issued a few months ago, revealed continued and substantial progress in spite of the war, and the company appears to be reaping the reward of their enterprise in applying scientific methods of training and development.

The Annual Report of the General Electric Co., Ltd., issued on July 5th, likewise shows a steady continuation of the progress of the last few years. The company's works have been largely occupied in the production of war-material, and many difficulties incidental to the war have been successfully overcome. It is interesting to note that following the appointment of Mr. J. Y. Fletcher as a director last year, three other of the younger members of the firm, Mr. M. F. Armstrong, Mr. G. H. Ide and Mr. Maurice Solomon have now joined the Board.

A considerable improvement is also recorded in the position of the British Thomson-Houston Co., whose Report was recently issued. Altogether the prospects of the leading electrical manufacturing firms appear bright and there is good reason to expect continued progress after the termination of the war.

EDISWAN ITEMS.

The Ediswan Discount tables, appearing in the form of a little pocket book, enable discounts at rates varying from 1/16 to 50 per cent. to be readily calculated on sums up to £1,000. In view of the large and varied discounts now allowed by the leading manufacturing firms the booklet should be of considerable service to those constantly engaged in quoting or estimating for installation work.

We have also received the latest list of Ediswan Electric Fans, for alternating and continuous current. A useful accessory is the Ediswan Dimmer Switch, which enables a 40-watt fan to be conveniently run at half speed.

· ELECTRICITY · · ACETYLENE ·
The
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· OIL · · GAS ·
Edited by
LEON GASTER

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EDITORIAL.

Concerted Effort in the Lighting Industry.

The steady tendency towards co-operation between different sections of the lighting industry is illustrated by several discussions that have taken place in the technical press during the past month. The Report issued by the Committee of the Institution of Electrical Engineers formed to prepare a programme to be submitted to the projected Board of Trade Committee on the Electrical Trades has naturally been the subject of comment, and in the gas journals the desirability of an analogous inquiry into some of the points raised in connection with the gas industry is suggested.

Again one of our electrical contemporaries, in pointing out the need for co-operative publicity, refers to the campaign so successfully undertaken for gas by the British Commercial Gas Association, and urges the need for a similar effort in furthering electric lighting. Thus each camp is on the alert to scrutinise and learn from the efforts of the other and to make good any omissions thus revealed in their own organisation.

At the present moment uniformity of policy is the more desirable in view of the problem of economising in coal supplies. If full advantage were taken of the resources of illuminating engineering, *i.e.*, if properly designed reflectors and modern lamps and burners were judiciously used, an economy of 10 per cent. in the lighting bills throughout the country could easily be made. The saving in coal from this source would probably amount to hundreds of thousands of tons. Gas and electric supply companies should, however, adopt a common policy in approaching the consumer utilising existing avenues of publicity and creating new machinery such as would be of great value after the war. No doubt a thoroughly efficient co-operative scheme of publicity in connection with electric lighting might be useful in this direction, and in normal times it would also be of permanent value to electric lighting and to the cause of good illumination as a whole. We should, however, like it to be understood that the excellent precedent set by the B.C.G.A. of stating the claims of the illuminant it represents, without attacking rival illuminants, should be followed.

A really successful movement in the direction of popularising the use of gas or electric lighting should enlist the support both of supply companies and of the local contractors and dealers in lighting appliances. We believe that by the help of the platform of the Illuminating Engineering Society a spirit of co-operation, helpful alike to the supply company, the dealer in gas and electrical accessories, and the public, might be brought about. Already many instances can be mentioned of results that could hardly have been attained except by the aid of this platform. For example, through the existence of this machinery, the Report of the Home Office Departmental Committee on Lighting in Factories and Workshops has already received much attention and become widely known to manufacturers, and will have an enormous influence on the industrial lighting of the future. Special mention may be made of the constant references to this Report in the advertisements of the B.C.G.A.—an enterprising and judicious step that might equally well have been adopted in connection with electric lighting. There are many other directions in which the claims of good illumination could be brought home to public authorities and Government departments, if only those concerned with lighting of all descriptions would co-operate in the illuminating engineering movement, in a fuller and wider way.

We see clearly that there is a strong tendency in this direction. There are many cases where the local authority owns both the gas and electric supply, and many dealers throughout the country who work both with gas and electric lighting and require further education in their correct use and applications. In the future, we believe, gas and electric concerns will draw closer together. The possibilities of joint effort in this direction were foreshadowed by Dr. Carpenter at the meeting of the South Metropolitan Gas Company this month when he said :—

> "I do not know whether the policy adopted by Parliament, of putting suppliers of gas or gaseous and electric energy into competition, has not had its day ; it may have. If one were to begin again, one would not do what one is doing to-day, viz., put up a large station to produce electric energy and another for gaseous energy. We should look to see whether these supplies should be undertaken separately, or whether there was not a great deal to be said on the point of economical working for running them together."

At the present time our activity in many fields of illuminating engineering is restricted by war conditions. But when peace returns once more there will be unrivalled opportunities for pressing home the need for better illumination in the streets, schools, public buildings, &c., throughout the country. We hope that these possibilities will not be neglected by gas and electric supply authorities throughout the kingdom. Valuable pioneering work in this direction has already been done by the illuminating engineering movement, but greater encouragement is necessary if complete success is to be attained.

Education and Scientific Research.

In our last number we referred to the Report issued by the Consultative Committee on Scholarships for Higher Education, and mentioned some instances of schemes being promoted to foster scientific education and research in various parts of the world.

During the past month there have again been several announcements of interest. The new President of the Board of Education is Lord Crewe, who, in view of his relation to the Imperial College of Science, will doubtless lend a sympathetic ear to proposals for developing scientific and technical education. His speech in the recent discussion in the House of Lords, which covered broad ground, might doubtless be taken as an indication of the intentions of the Government.

The Prime Minister has appointed two new Committees (1) to inquire into the position occupied by Natural Science in the educational system of Great Britain, and to advise what measures are needed to promote the advancement of pure science and the interests of trades, industries, and professions depending upon Applied Science, and (2) to conduct a similar inquiry into the position occupied by the Study of Modern Languages.

Another item of interest is the issue of the Memorial by the British Science Guild, which contains a number of suggestions for securing to science a more adequate representation in the national educational programme and in Governmental affairs, special reference being made to the need for scientifically trained men in certain departments of the Civil Service.

Readers will also recall the conference called by the Royal Society some months ago to consider the formation of a Board of Scientific Societies, with a view to securing the co-operation of those interested in pure and applied science, promoting the application of science to industry, and discussing questions on which international co-operation seems advisable. According to a recent announcement the Board at present consists of representatives of twenty-seven scientific and technical societies. An executive committee has been appointed, consisting of Sir Joseph Thomson (Chairman), Dr. Dugald Clerk, Sir Robert Hadfield, Mr. A. D. Hall, Prof. Herbert Jackson (Hon. Secretary), Sir Alfred Keogh, Sir Ray Lankaster, Professor A. Schuster, Sir John Snell, Professor E. H. Starling, Lord Sydenham, and Mr. R. Threlfall. The first meeting of the Board was held on July 20th, and it is evident that the scheme is now assuming concrete form.

Naturally in the case of a scheme of this magnitude a good deal of preliminary discussion is needed, but it would be helpful if a fuller statement of the intentions of the Board and the proposed methods of enlisting the co-operation of scientific and technical societies throughout the country, could be made at an early date. There is doubtless a very considerable number of such societies anxious to participate in the scheme and awaiting further information; and, as many of them are already engaged in work which involves some degree of co-operation, publicity would be helpful in suggesting how such work could be co-ordinated with the programme of the Conjoint Board, and how possible overlapping of effort could be, so far as possible, avoided.

Problems in Phosphorescence and Luminescence.

On page 249 we make a few notes on a most interesting lecture on "Radium and other Luminous Compounds," delivered by Mr. F. Harison Glew before the Optical Society (London) last June.

To the illuminating engineer the principles involved in the behaviour of these self-luminous substances are of great scientific interest. The war has brought before us a number of special applications for these materials, and who can say what their possibilities may be in the future? The mysterious production of light by the firefly has often been referred to as an example of "cold light," and there have been attempts to isolate and prepare synthetically the substances from which the luminous effect appears to proceed. For many years, too, it has been known that certain sulphides would, after exposure to daylight, continue to emit light in the dark, and the writer has a very vivid recollection of some experiments in this direction shown him by Mr. W. J. Hammer during a visit to the United States in 1907. It appears that the excitation of this luminous effect is accomplished mainly through the presence of ultra-violet rays and, now that we have available sources of light which are relatively rich in this form of radiation, the study of these effects would be of great interest to lighting engineers. Chemists and physicists have carried out many researches in this field, but there still remain many problems which have not yet been properly investigated, and require for their solution the combined efforts of the chemist and the photometric expert.

Little has been published regarding the intensity and duration of the luminosity excited in these materials. When the paint has been exposed and removed to a dark chamber the initial brightness gradually diminishes. The efforts of experts will doubtless be concentrated on the problem of increasing the intensity and duration of this effect. The problem of producing paint which will retain its brightness, without the necessity for exposure to daylight, is of distinct practical importance. In order to secure a relatively "permanent" effect the sulphide material is mixed with a minute percentage of a radio-active substance, by which it is continually excited, thus giving a steady glow. In this form the paint has many applications for underground work, for outlining the figures on dials of watches and scientific instruments, and for other special purposes.

It appears that at present the surface-brightness of freshly prepared material may approach a value equivalent to 0.03 ft.-candles, which is approximately twice the luminosity of a white surface illuminated by strong moonlight. The rate at which this initial brightness diminishes seems to depend on many factors, such as the percentage of radio-active material combined with the luminescent sulphide.

If it were possible to produce the exciting element in much larger quantities, the high cost of this self-luminous material might be diminished, and this would naturally lead to a great extension in its practical applications. Radium is still an expensive article. A possible substitute mentioned by Mr. Glew is mesothorium, which, if capable of manufacture on a large scale, may prove of some value.

The whole subject is a most fascinating one, and deserves closer investigation in the immediate future.

LEON GASTER.

SOME PROBLEMS IN THE USE OF ELECTRIC INCANDESCENT LAMPS.

By an Engineering Correspondent.

The question of the rating of lamps has been recently much discussed in this journal, especially in connection with the variations in distribution of light from gas-filled lamps. There is a growing recognition that the only satisfactory basis of comparison is in terms of the total output of light—either mean spherical candlepower or lumens. It is not proposed to go over this matter again; but it is of interest to mention some striking figures published by R. C. Robinson*, in the United States. A comparison was made between four types of gas-filled lamps, having differently shaped filaments. The watts per mean horl. c.p. varied between 0·595 and 0·82, whereas the mean sph. c.p. per watt was substantially the same in each case. This shows that horizontal candlepower is not a satisfactory basis of measurement even for when comparing gas-filled lamps with one another—still less in when comparing gas-filled lamps with other illuminants.

Life and Efficiency.

Another fairly well established point is that the use of the term "half-watt" lamp is unsatisfactory. "Gas-filled" lamp is a better description.

While the higher candlepower units may operate at about 0·6 watts per candle (horizontal) the high voltage, low candlepower units, it is well known, do not work at this efficiency. Generally speaking, it seems best not to describe any type of lamp by a term indicating its efficiency, especially as, in view of the rapid progress being made in the improvement of such lamps, any such term may require revision later on.

At present but few impartial records of the life of such lamps have been published in this country. According to some curves given in an article by Pirani and Meyer* in Germany last year, the specific consumption, of 1000 watt 220 v. gas-filled lamps increased, in the course of 1,000 hours, from 0·55 to 0·7 watts per H.K. (approx. 0·6—0·77 watts per candle). In the case of the 60 watt 110 v. lamps the corresponding change was from 0·72—0·88 watts per H.K. (approx. 0·8 to 0·96 watts per candle). The initial lumens per watt were given as 14·0—22·8 for various types (roughly equivalent to a range of 0·6—1·0 watts per candle (mean spherical).

While these figures may be regarded representative of good lamps, in the case of inferior types less satisfactory results might doubtless be obtained. The difference between a good and poor lamp is probably even greater here than in the case of ordinary tungsten lamps The manufacture of the latter has become more or less standardised, and the general level of excellence is much higher than a few years ago. Gas-filled lamps, on the other hand, are still a novelty, and their manufacture is less stereotyped. Moreover, their performance is effected by a variety of factors. For example, G. S. Merrill † recently published some life-curves, illustrating the effect of the method of spacing the coils of the filament. In the gas-filled lamp a balance is struck between the increased temperature of the filament and the heat-losses conducted through the surrounding gas A change in the coil-spacing of the filament during life exposes a larger superficial area, thus diminishing the temperature of the filament. Presumably this might result in a longer actual life; but at the same time efficiency of the lamp might diminish by 10—15 per cent.

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* Trans. Ill. Eng. Soc., U.S.A., November, 1916.

* Elektrotechnische Zeitschrift, Nos. 38 and 39, 1915.

† Trans. Ill. Eng. Soc., U.S.A., June, 1916.

When should Gas-Filled Lamps be Used?

This leads us to an important point for consumers. Under what conditions is it preferable to use gas-filled lamps rather than ordinary tungsten lamps? Many people have very hazy ideas on this point, and it would be a help if manufacturers who are concerned with both varieties of lamps would publish data in their catalogues, indicating roughly the circumstances in which each type of lamp is best. No one now doubts that there is an important field of usefulness for the gas-filled lamps of high candlepower. On the other hand, when the voltage is relatively high, the cost of current low, and the type of unit desired of small candlepower, their advantages of gas-filled lamps are at present less evident. The lamps are still relatively costly, and consumers cannot always be induced to keep an adequate stock in hand. The dissatisfaction caused by several failures without means of replacing them makes a deep impression, even though the consumer may himself be partly to blame in the matter. Irregularity of life is more troublesome than a life which, though relatively short, can always be relied upon.

From a series of comparisons recently carried out by the writer (taking into account cost both of energy and of replacing lamps), it appears that high candlepower gas-filled units (300 c.p. or over), will in general be more economical than ordinary tungsten lamps if the cost of energy is over 1½d.--2d. a unit. On the other hand, experience suggests that the small 100 watt high voltage units are at present usually less economical than the vacuum lamps, even if the cost per unit is in the neighbourhood of 3d. or 4d. a unit.

Other Circumstances affecting Performance of Gas-filled Lamps.

One meets great diversities in experience with gas-filled lamps, especially the smaller units. In some cases everything goes well; in others unexpected failures cause a lot of trouble. No doubt in some instances the irregular life may be attributed merely to bad luck in getting a poor batch of lamps (and consumers are apt to remember an unfortunate experience and forget the times when all goes well!).

But there are other suggested explanations which seem to deserve investigation. One factor is the regularity with which the lamps are used. The writer recalls a conversation with a railway engineer in the early days of metal filament lamps, in the course of which he was informed that the average life on this particular section of the line amounted to several thousand hours, while lives of even 7,000 hours were not unknown. In view of the opinion generally held at that time that metal filament lamps were not yet adapted to withstand the vibration of railways, this seemed remarkable. The explanation apparently lay in the fact that the lamps were kept burning almost continuously, and were rarely switched off. On the other hand, when a carriage was detached and left in the shed for a night, it was often found that quite a number of the lamps failed on switching on.

The tendency to fail when switched on, owing to the high initial current through the cold filament, was a characteristic of early tungsten filament lamps. It is possible that this temporary surge of current, which is accentuated in the gas-filled lamps, has an appreciable effect on their life, especially in the case of the finer filaments. According to the oscillographic records of Pirani and Meyer (*loc. cit.*) the initial current may be as much as 15 times the final value, and it may take 0·3 seconds before the steady value of the current is attained. A similar effect occurs on breaking, and the writer was recently informed by an engineer engaged in some experiments involving much making and breaking that special rotary quick break switches were found necessary. The switches previously used would break 8 amperes satisfactorily on an 8 ampere arc-light circuit, but would not answer on a 4½ amp. circuit containing gas-filled lamps.

It therefore seems advisable to limit the switching on and off of such circuits as far as possible. This is confirmed by the experience in certain works, where the lamps are kept running for day- and night-shifts, and are only rarely extinguished, and where excellent results as regards average life have been obtained. In munition works, which are running day and night, this is a point worth noting.

Another question which has been raised in connection with gas-filled lamps, and seems to deserve attention, is the effect on the life of lamps of enclosing them in globes or fittings with inadequate ventilation. Owing to the heat developed in these lamp fittings they require special design. Does the mere fact of enclosing a lamp in a globe or reflector, which may limit the radiation of heat, and appreciably affect the temperature of the lamp as a whole, affect its life? Statements to this effect have been made in regard to high candlepower tungsten lamps of the ordinary variety, and there is a general impression that the practice of covering lamps with coatings of lacquer, which has become usual since the outbreak of war in order to comply with the lighting regulations, materially shortens their life. Some years ago it was even suggested that changes in atmospheric temperature might have an appreciable effect on the candlepower of standard electric incandescent lamps, although the experiments of the writer and others failed to obtain confirmation in this case. But if, as seems possible, the enclosure of ordinary vacuum lamps has any influence on their life, one would expect this effect to be accentuated in the case of gas-filled lamps, the filaments of which are run at a higher temperature. The matter deserves scientific investigation. Should this suggestion be confirmed it would afford another reason for preferring well-constructed fittings which, besides improving the distribution of light, are specially designed with a view to affording adequate ventilation.

LAMPS ON ALTERNATING CURRENT.

The last point which the writer desires to raise is the effect on vision of such fluctuations in light as occur in lamps run on alternating circuits. It is well known that the cyclical variations in the light from arc lamps run on an alternating P.D. may be rendered quite evident. Whether or no they are perceptible to the eye, or have any fatiguing effect on it, when the observer is working with stationary materials, is doubtful. But if such a light is used to illuminate rotating machinery "stroboscopic" effects may be produced. Machinery which is in motion may appear stationary if the period of revolution coincides exactly with the cyclical variations in the light of the illumination. In certain circumstances the apparent direction of revolution may even be reversed, *e.g.*, the teeth of a lathe lighted by an alternating arc may appear to be moving backwards. Similarly quick motions of an implement in the hand of a workman produce a succession of moving images—which is naturally distracting. It is in fact generally recognised that alternating arcs are unsuitable for the illumination of processes involving rapid manipulation.

If an incandescent lamp is run on a circuit of low periodicity (as, for example, a frequency of 25), the variations in brightness are perceptible to the eye, and similar effects might be produced. The effect is naturally most pronounced with tungsten lamps of low candlepower, having thin filaments which cool and heat more readily.

But it has generally been assumed that in the case of an ordinary lighting circuit (with a frequency of 100 or 50), the effect is inappreciable. Experiments have shown that a flicker photometer cannot be conveniently used for testing an alternating arc owing to the production of stroboscopic bands; but no such effect could be detected on an ordinary lighting circuit with incandescent lamps. This is a fairly delicate test.

The question has been raised anew by E. A. Salt, in an article in the *British Journal of Photography*.* The author finds that a glow lamp fed from an alternating circuit is unsuitable for retouching work, and attributes this to the fluctuations in light. The existence of such fluctuations was demonstrated as follows.

A slit was illuminated by a 200 volt 20 watt incandescent tungsten lamp on an alterating circuit with a frequency of 50. An image of this slit was projected on to a photographic plate which was rotated during half a second, and subsequently developed. If the lamp had given a steady light a band of uniform brilliancy would be expected. Instead of this a series of a hundred bright bands, corresponding with the reversals of the light, was obtained. A 55 watt 200 volt lamp gave a similar result.

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* Alternating Current and Eyestrain, *Brit. Journ. of Photography*, July 7, 1916.

This experiment shows the existence of cyclical variations in the light. It does not, as the author remarks, indicate the extent of the variation (which would be accentuated or diminished according to the exposure), nor does it in itself give any information as to its effect on vision. When one looks at such a lamp run on an ordinary A.C. lighting circuit the variations in light occur too quickly to be perceived by the eye. It is not quite clear whether the unsuitability of this light for retouching arose through the production of stroboscopic effects and moving images of the pencil, or whether, in the opinion of the experimenter, the light would have been equally trying even for the illumination of stationary objects.

The matter is one which ought to be cleared up. Common experience suggests that there can be no very marked disadvantage in the use of incandescent lamps on alternating circuits for ordinary work, but it is conceivable that in certain circumstances it might have drawbacks, for example, in very fine work, carried out over long intervals of time, with moving implements. Here a small, but appreciable stroboscopic effect might have a cumulative effect.

It is also possible that, even when no change in brightness can be detected by looking at the lamp, minute fluctuations in brightness might be perceived when the eye is directed on illuminated stationary objects. This would depend on many factors, such as the illumination used and the extent of the variations in light produced in the lamp. Experience with flicker photometers shows that, even with a brightness-variation of 20 per cent., flicker becomes inappreciable with a frequency of 30 per second.* It hardly seems likely that on an ordinary lighting circuit, with a frequency of 50 or 100, the variations in the brightness of illumination produced by an incandescent lamp would be perceptible.

There is also the further distinct question whether such cyclical variations, even though not directly revealed to the eye, either in the form of visible fluctuations or stroboscopic effects, may have a cumulative influence on vision.

Conceivably even those changes occur too rapidly to be recognised, they might have a fatiguing effect on the nerves controlling the eyes. From this broader aspect even the relatively small variations which occur on an electric direct circuit or gas supply deserve consideration. It is of course true that the variations in daylight are far greater than those met with by artificial light, but these natural fluctuations take place comparatively slowly and the eye can accommodate itself to them. Perhaps, in the smaller but more abrupt fluctuations that occur with artificial light, we have one explanation of the general acceptance of daylight as the best available form of illumination, and of the preference still often expressed for the steady mellow light of the oil lamp.

The whole question is essentially one for the physiologist to investigate. In the interests of illuminating engineering, it ought to be definitely settled.

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* Trotter, "Illumination; its Distillation and Measurement," p. 180.

GERMAN ILLUMINATING ENGINEERING SOCIETY.

We notice that the next annual meeting of the German Illuminating Engineering Society has been announced to take place at Nuremberg on September 16th, Prof. Warburg presiding.

Among the papers to be discussed are :—"Technical Aspects of the Cathode Rays," by Dr. Norden; "The Limits of the Production of Light by Temperature Radiation, the so-called Mechanical Equivalent of Light, and the existing Incandescent Lamps," by Dr. Meyer; and "Factory Lighting," by N. A. Halbertsma.

RADIUM AND OTHER LUMINOUS COMPOUNDS*

To the lighting engineer phosphorescent and luminescent substances have always appeared a fascinating field for study. Several interesting investigations on this subject have been made in the United States from time to time, such as the analysis of the light from the fire-fly carried by Ives and Coblentz, and the researches on phosphorescence of Prof. Nichols of Cornell University. The light yielded by various phosphorescent insects varies much in colour, intensity and duration. Possibly in the future the chemist, by analysing the substances from which this light is derived, may eventually be in a position to produce synthetically a substance glowing brightly enough to have important practical applications.

In theatrical displays, the glow from various substances which phosphoresce after exposure to ultra violet light has already been utilised, and as we have now available sources of light which are very powerful in rays of this description the whole matter is worth study. Recently public attention has been drawn to the applications of such substances for various military purposes, for example in coating the dials of watches and instruments, star-maps, &c.

The recent lecture by Mr. F. Harrison Glew before the Optical Society was, therefore, very timely. The lecturer showed a number of striking experiments and gave much information on one section of the subject, the effects of radioactive substances on luminescing materials, of which little is generally known.

The phosphorescence of insects is apparently due to the oxidation of an organic fluid and fails under the head of "Chemi-luminescence." Some substances, such as quartz, sugar, fluorspar, &c., become luminescent when rubbed. This is termed "Tribo-luminescence." Again, there are certain crystals which after exposure to radium, will emit light under the action of heat ("Pyro-luminescence"). For example, a sample of spodumene, which had previously been placed in proximity to a large quantity of radium, becomes intensely luminous when heated, giving a beautiful orange glow.

The most familiar example of phosphorescence, however, is the behaviour of the so-called "luminous," or Balmain's paint. There are a number of substances, such as sulphide of zinc, which after exposure to light become themselves luminous, the brightness rapidly decaying, but remaining perceptible for hours. Mr. Glew showed how, by the rotation of cylinders coated with such substances (so that they are alternately exposed to the light from an arc and withdrawn), a very brilliant brightness, comparable with that produced by a 16 candle-power lamp at a distance of a few feet, could be produced; but this order of brightness is very transient. Nevertheless, the brightness still persisting after several hours may be sufficient to have some utility, and zinc sulphide and other substances have already found practical applications in this form. Zinc sulphide produces a greenish light, but by using other materials, blue, yellow, and even red light can be obtained, and spectacular luminous pictures of landscapes, &c., produced.

The most important application of these substances, however, is the form of the so-called "self-luminous" or permanently luminous paints. These do not need to be exposed to daylight or other appropriate illuminant in order to store up energy which is afterwards reproduced as a luminous glow, but give a continuous and steady light. This is accomplished by mixing the luminescing material with a minute proportion of radium bromide or its equivalent. Radium, like ultra-violet light, has the property of exciting luminosity in these substances, and, as it acts continuously, we get a permanent luminous effect. The initial brightness depends on the percentage of radioactive material mixed with the paint, and the rate of decay of this brightness depends on the initial value attained. (For example, the lecturer stated that two samples, prepared respectively with 0.4 and 0.2 milligrams of rad. bromide, had arrived at equality of brightness after eight months' use; thus the weaker preparation, though yielding originally the feebler light, has the longest life.)

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* Notes on a Lecture delivered by Mr. F. Harrison Glew, before the Optical Society of London, June, 1916.

The lecturer also touched on other possible stimulants for luminous paints, such as meso-thorium.

An interesting point is the method of measuring the brightness of luminous paints. The low luminosity (radium paint prepared to the Admiralty specification has a surface-brightness, when new, of 0.03 ft.-candles) and peculiar colour present difficulties, but for purely comparative work the latter difficulty can be overcome by viewing the surfaces whose brightness is compared through a gelatine of a yellow-green tint.

THE PROJECTING LANTERN.

By J. B. Taylor.*

A recent paper on the above subject, read by J. B. Taylor before the American Illuminating Engineering Society, summarises the fundamental principles of optical projection. Many expert operators hold the view that a more powerful light is needed to illuminate a picture 40 ft. away from a lantern, than when the screen is only 20 ft. away. Actually, if the picture is the same size, there should be no difference, as the same flux of light is used in both cases.

If, however, a larger picture is obtained in one case than the other, the brightness is naturally correspondingly reduced. The author discusses the intensity of brightness needed for lantern slides. From data obtained in this country and published previously in this journal, it appeared that one foot-candle in the whites was ample. This is confirmed by Mr. Taylor's statement that even ½ foot-candle has been used with satisfaction, although on occasions operators may use a brightness ten times as high. Another interesting point is the use of special semi-polished and translucent screens, which depart widely from Lambert's law. By such methods a much greater brightness can be obtained for a given flux of light in the case of those immediately facing the picture; but to those at the sides the picture appears relatively dark, so that it is only in exceptional cases that such screens can be conveniently used.

As regards the lighting of the theatre Mr. Taylor lays stress on the avoidance of bright points of light (indicating exits, &c.), which distract attention from the picture, and on the need for allowing time for the adaptation of the eye to the dark surroundings before a film is commenced.

In the discussion of this paper H. Gage referred to a very complete and perfect type of instrument which could be adapted for the projection of lantern slides, cinematograph films, and microscopic solid objects (on the epidiascope principle). For microscopic projection great flexibility is needed as it is frequently necessary first to show a subject as a general view and then portions of it on a larger scale. In the case of opaque projection only about 3 per cent. of the diffusely reflected light will go through a large-sized objective. This speaker also mentioned the following figures for the desirable brightness of the screen :—

	Ft.-candles.
In a dark room—	
Lantern slides ..	2.5
Microscope specimens	1
Moving pictures ..	3
In a room lighted from back— (0.7 ft.-candles general illumination) ..	6

Mr. M. Luckiesh remarked that the two chief causes of eye-strain in cinema work are unduly severe contrast between the brightness of the screen and the surroundings, and the flicker of the film. A moderate general illumination is desirable, although this will necessitate a somewhat higher brightness of the screen. There also seems reason to suppose, from experiments in flicker photometry, that the point at which flicker becomes evident depends to some extent on the illumination of the screen. This point deserves further investigation.

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* Trans. Ill. Eng. Soc. (U.S.A.), May, 1916.

BRITISH SCIENCE GUILD.

Memorandum on Proposed National Statutory Board of Science and Industry.

An important memorandum on the above subject has just been issued by the British Science Guild, which has received the signature of many eminent men connected with science and industry. It is pointed out that " the present European crisis affords a unique opportunity of impressing upon all who are engaged in the executive functions of government, as well as upon those who are concerned with industry and commerce, the paramount importance of scientific method and research in national affairs."

After dwelling on the great advance in national prosperity brought about by the practical applications of science, and on the need for further encouragement of scientific investigation by the State, the memorandum presents a series of seven recommendations, which may be summarised as follows :—

(i) The formation of a National Statutory Board of Science and Industry, the permanent staff of which should consist mainly of persons of wide scientific knowledge and business experience. The functions of this Board would include the promotion of co-operation between manufacturers and laboratories for research ; the co-ordination of scientific effort through joint scientific committees ; the collection and publication of scientific and technical information ; the institution of a number of paid advisory committees consisting of men of wide scientific knowledge, assisted by expert investigators and technologists, who should receive reasonable fees for their services ; the mobilisation of the scientific industrial and educational activities of the nation so as to ensure ready response to national needs and emergencies.

(ii) In all departments of State in which scientific work is carried on, adequate provision should be made for the periodical and wide distribution of leaflets and reports, so that increased public interest and attention may be encouraged in the results.

(iii) Every industrial undertaking subsidised or otherwise assisted by the State should have upon its Board of Directors men who possess expert scientific knowledge of the business in which they are engaged.

(iv) Adequate remuneration and improved prospects should be offered by the Government, by Municipal Corporations, and by manufacturers to men who have received an effective scientific training. Means should be found of compensating and rewarding persons whose researches have proved of decided national or public advantage without being profitable to themselves.

(v) A knowledge of science should be regarded as an essential qualification for future appointments in the departments of the public service concerned with industrial, scientific, and technical developments. A committee, on the lines recommended by the Royal Commission on the Civil Service in 1914, should be appointed to consider the present syllabus of subjects for examination for clerkships, and science should be adequately represented upon it.

(vi) Measures should be taken to revise the educational courses now followed in the public schools and the Universities of Oxford and Cambridge.

(vii) In elementary and secondary schools supervised by the Board of Education, more attention should be given to scientific method, observation and experiment, and to educational handwork.

RESEARCH UNDER THE BIRMINGHAM GAS DEPARTMENT.

An interesting departure by the laboratory of the Birmingham Gas Department is reported. For some years special researches have been conducted in connection with the applications of gas, but it is now proposed to widen the scope of these inquiries in order to include other experiments of general value to manufacturers. Captain Hilton, the secretary and manager of the Birmingham City Gas Department has been approached on this matter by organised bodies of local manufacturers, and it is proposed to extend the activities of the laboratory by engaging the services of a staff of experts having adequate theoretical training and a knowledge of the applications of science in specific industries.

The laboratory will conduct researches of general utility by which manufacturers as a whole may benefit, and will also carry out confidential investigations for individual manufacturers.

CO-OPERATION BETWEEN THE GAS COMPANY AND THE ARCHITECT.

An article by D. Knickerbocker, a consulting architect of Philadelphia, read at the mid-year conference of the National Commercial Gas Association in the United States,* makes some suggestions as to opportunities for co-operation between gas companies and architects, on whom the lighting and heating arrangements of many buildings depend.

He lays stress on the value of bulletins giving prompt and practical information of novelties in gas heating and lighting, and containing such particulars as an architect would naturally require, and points out the need for standardisation of procedure in piping buildings. Practical information on hot-water supply is particularly needful to the architect.

In electric lighting his work is simplified by the National Electrical Code, adopted by the leading electrical companies and professional societies throughout the United States; this is invariably required by the Board of Underwriters, without whose certificate the fire insurance companies will not issue policies of insurance. The architect, therefore, inserts in his specification a clause requiring work to be done in accordance with the National Electrical Code.

In gas lighting, however, there is no such generally accepted code, and architects commonly employ general wording to the effect that "the best quality must be used," or "the work carried out to the satisfaction of the architect," &c. This leaves room for misunderstanding in view of the varied practice of local gas companies in different States. "A National Basic Code with a piping schedule of minimum standards for sizes, lengths and weights would therefore be of the greatest advantage. . . ." A schedule has already been formulated by the B.C.G.A., and would form a nucleus of a final code if taken up and formally adopted, with suitable modifications by the American Gas Institute, the American Institute of Architects and other interested bodies.

Such a standard Schedule would then be adopted throughout the United States. At present some local authorities and gas companies have adopted excellent rules. In Philadelphia, for example, the ordinance authorising the United Gas Improvement Co. to lease the Philadelphia Gas Works, requires the company to exercise supervision over the work and material used and specifies the exact rules to be complied with.

But the adoption of a general series of rules applicable everywhere would smooth away many difficulties and would be helpful in securing an improvement of conditions in many localities where old-fashioned and unsatisfactory methods of piping are still in force.

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* *Intercolonial Gas Journal of Canada*, Aug. 1916.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

A Report presented by the Committee on Progress (Mr. F. E. Cady, *Chairman*, Mr. T. J. Litle, Mr. L. B. Marks, Mr. T. W. Rolph), at the Ninth Annual Convention of the Illuminating Engineering Society, held in Washington, September 20th to 23rd, 1915 ; slightly abbreviated.

(*Concluded from Vol. VIX., July* 1916, *p.* 230.)

Reflection.—Now that semi-indirect and totally indirect lighting systems are coming more and more into use, the effect of the walls and ceilings in reflecting light is of great importance. The results of considerable work on tests of the reflecting power of paints have been presented. The[145] colours examined ranged from white to dark buffs and greens. The highest coefficient obtained was 0.657 which was for a white oil paint of medium gloss. Less than one-half of the samples tested showed coefficients above 50 per cent. and all of those that did so were of very light creamy or yellowish tones. A rather light olive colour gave only 0.328.

Code.—Reference should be made to the very important work of the Committee on Lighting Legislation and the Factory Lighting Committee of this society, as a result of which a code on the lighting of factories, mills and work-places has been prepared.

Globes, Reflectors and Fixtures.

Having plenty of light available either from gas or electricity manufacturers have increased the variety of materials used in making globes, reflectors and shades. At one extreme might be put the wicker basket, which provided with or without a lining is used suspended from the ceiling as a semi-indirect fixture, or inverted and covered with suitable material, it makes a shade for a table lamp. At the other extreme might be put the hammered brass bowl with or without glass inserts and used either for totally indirect or semi-indirect lighting. There is a growing use of floor lamps having very large shades and mounted on standards 5 or 6 ft. (1.52 or 1.82 m.) high. Such a lamp is replacing the old centre table lamp for family reading and inasmuch as those using it can all have the light properly directed for reading purposes, it forms a step in the direction of eye protection. There is also a growing trend on the[146] part of architects to call for lighting fixtures which conform to the period of their surroundings.

In schoolrooms an increasing tendency toward the use of denser glassware with the semi-indirect lighting method is noticeable and in general for both direct and semi-indirect system the denser glassware is used. Furthermore the tendency towards constantly increasing candlepower in small units has led to a greater use of diffusing media such as marble and alabaster, and to fixtures carrying several lights burning upright with small semi-indirect shades. The use of cloth for shades is growing and an umbrella manufacturer has developed[147] a collapsible shade of cretonne, which can be folded up, when not in use, for packing or storage purposes.

A novel arrangement has been brought out in England[148] for converting a dining room fixture into a combined direct and semi-indirect unit. A double cone of white silk is employed in conjunction with the common "corona band" so that the lamp occupies a position in the lower cone, when the fitting is at the usual height, giving light directly downward, while at another height the lamp moves up into the upper cone, with the light directed toward the ceiling.

For the modern very large office building an equipment of specially designed fixtures is not uncommon. In one case of this kind[149] a fixture was developed which can be utilized either for direct, semi-indirect or totally indirect lighting. There is evidence[150] of a considerable increase in the employment of the semi-indirect type of fixtures for gas.

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[145] *Elec. World*, Jan. 23, 1915, p. 211.

[146] *Elec. World*, Apr. 3, 1915, p. 871.

[147] *Light. Jour. and Eng.* (Lond.), Feb., 1915, p. 81.

[148] *Ill. Eng.* (Lond.), Mar., 1915, p. 103.

A great advance has been made in gas fittings.[151] The old "goose neck," fastened with a wire, is being replaced by straight pipe tubing with gas-tight adjustable couplings, which make a variety of brackets available.

Reflectors have been developed for converting[152] the ordinary gas arc as used in stores and warehouses into a semi-indirect unit, thus meeting the demand for this type of lighting without the necessity of scrapping former fixtures. The advent of the 100-watt, gas-filled tungsten unit has caused the development of prismatic and mirrored reflectors for use in show-window lighting.

In lighting fixtures of ornate design and equipped with electric candle or candelabra lamps the use of ordinary key or pull sockets for individual lamp control is often undesirable and esthetically objectionable. A rotating switch has been devised to meet[153] this condition, which is operated by turning an outer sleeve forming part of the candle. The replacing of arc lamps by the new high efficiency tungsten lamps has resulted in an[154] adaptation of the fixtures of the former to act as housings for the latter. The principal change needed is the introduction of baffle plates to prevent the entrance of rain without hindering the ventilation. For all classes of outdoor lighting by electricity fixtures have been designed which include[155] not only adaptability to series or multiple circuits, to pole or cross-span suspension, but also ventilating and enclosing glass ware if desired, so that a complete equipment is available in one fixture.

A reinforced-concrete lighting standard of attractive design and appearance is being installed[156] in a number of California cities including beach resorts, where metal standards have suffered severely in the past owing to the action of salt air.

Photometry.

The measurement of light sources differing in colour value continues to interest the photometrist. Developments have followed two general lines, one the elimination of the colour difference, thereby reducing conditions to those of ordinary photometry, the other the use of the flicker photometer which has not yet been generally accepted as a solution of the problem.

Secondary Standards.—At the National Physical Laboratory in England there has been completed and described[157] a careful and exhaustive research having for its object the establishment of a set of standards matching in colour lamps operating at the various efficiencies in ordinary use. In this research the colour problem was met by using the so-called "Cascade" method in which a lamp at a given watts per candle is measured against one whose watts per candle differs by an amount which will make the colour difference small enough not to be objectionable. Check measurements were also made in which the maximum colour difference was encountered. The experience gained from these and other comparisons was that whereas an observer may be relied upon for constancy of judgment in measuring with an ordinary contrast photometer sources differing by a small amount in colour value, the same constancy in judgment was not obtainable where the colour differences were large. Efforts were made to use the flicker photometer but the results were not satisfactory and the accuracy was of a different order of magnitude from that found with the other method.

Colour Difference.—It is rather interesting to note that elsewhere[158] in observations on colour differences made with a flicker photometer and extending over a year, individual observers reproduced their results with very few exceptions.

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[149] *Elec. World,* Feb. 20, 1915, p. 490.
[150] *The Gas Age,* Jan. 1, 1915, p. 8.
[151] *Light. Jour.* (U.S.), Dec., 1914, p. 281. *Proc. Amer. Gas Inst.,* vol. IX, 1914, p.886.
[152] *Amer. Gas Lt. Jour.,* May 3, 1915, p. 286.
[153] *Elec. Rev. and W. E.,* May 29, 1915, p.1005.
[154] *Elec. World,* May 1, 1915, p. 1131.
[155] *Elec. Rev. and W. E.,* July 24, 1915, p. 167.

[156] *Elec. World,* Apr. 3, 1915, p. 874.
[157] *Phil. Mag.,* July, 1915, p. 63.
[158] TRANS. I. E. S., Apr. 30, 1915, p. 207.

The colour screen method of eliminating the colour difference in heterchromatic photometry has been extended by the development[159] of a blue solution, which in varying degrees of saturation will provide a colour match between a standard carbon lamp and another lamp operating at any watts per candle from 3·1 to 0·5. An alternative for[160] the colour absorbing solution in eliminating colour differences is suggested in a new photometer using polarised light. It is based on the rotation of the plane of polarisation by a quartz plate and the fact that this rotation is different for light of different wave-lengths.

Flicker.—By applying to a modified form of the Conroy photometer[161] an oscillating platinised mirror and adding an optical wedge having its density gradient vertical and different by two per cent. from top to bottom a new flicker-photometer has been developed. Another arrangement[162] for a flicker-photometer consists in a modification applicable to the ordinary Lummer-Brodhun photometer head. A tube, replacing the ordinary eye-piece, carries a rotating prism. Means are provided for illuminating the surrounding field and for accurate speed control.

A theory of the flicker-photometer has been presented in[163] which the behaviour of the instrument is deduced directly from the relationship of critical frequency and illumination. It is assumed that a fluctuating stimulus is transmitted as a considerably dampened fluctuating impression whose form and amplitude can be calculated by using the Fourier linear diffusion equation. The same line of reasoning is used to explain the relationship of colour flicker to brightness flicker. Further work[164] has also been done on the question whether results in colour photometry obtained by the flicker method and the acuteness of vision method are the same. The data obtained in these experiments indicated they are. A Lummer-Pringsheim spectro-flicker-photometer was employed and experiments made with foveal vision and portions of the retina lying 20° to 30° outside the direct line of sight. Means have been provided,[165] using coloured absorbing media for correcting an abnormal eye. It is claimed that by the practical application of this method to the flicker-photometer it is possible to equip any observer so that he will read correctly colour differences of a given type ; and to equip a colour-blind observer so that he will not only read such differences correctly, but also measure other colour differences with no more uncertainty than a random observer of " normal " vision will do.

Integrating Sphere.—At the last convention there was quite a discussion on the best paint to use for the inner diffusing surface of an integrating sphere. An elaborate research was undertaken in Germany[166] to decide not only this point but also the best material of which to make the sphere itself. The results indicated that iron plate is to be preferred to zinc for the construction material and that zinc white as the diffusing surface gives the best results.

New Instruments.—In the photometry of phosphorescent gases and certain phosphorescent solids, the light to be measured is of rapidly diminishing intensity. In order to ascertain the errors occurring in the measurement of such a light a modification of the ordinary photometer has been devised[167] in which the essential feature is a sliding carriage supporting one of the lamps and capable of being set in to and fro motion at uniform velocity in the photometric axis. Means are provided for recording the position of the carriage while in motion. Using this instrument an investigation showed that errors as high as 15 per cent. or more and apparently due to retinal fatigue, may occur in the photometric of phosphorescent decays.

A new portable illumination photometer has been brought out[168] which is a modification of the Weber type and much more compact. Another illuminometer[169] has been described for use where rapid and rough measurements of light intensity are desired. In this instrument a screen of black silk illuminated from the rear is viewed in comparison with tinted sectors, on which falls the illumination to be measured. The intensity of the light from the comparison lamp is controlled by an iris diaphragm. As a quick means of determining the various energy relations in tungsten lamps, a direct reading instrument has been devised[170] using data presented at the last convention.[171] It is made up of volts, watts per candle and per cent. candlepower scales. The volt scale has a range from 94 to 166 volts, while the watts-per-candle scale limits are 0·70 and 2·05. Knowing any two relations the other may be calculated within the range of the instrument.

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[159] TRANS. I. E. S., Apr. 30, 1915, p. 253.
[160] *Phys. Rev.*, July, 1915, p. 64.
[161] *Phys. Rev.*, 4, 1914, p. 477.
[162] *Light. Jour.*, May, 1915, p. 111.
[163] *Phil. Mag.*, May 28, 1915, p. 708.
[164] *Ann. d. Phys.*, Aug. 14, 1914, p. 105.
[165] TRANS. I. E. S., Apr. 30, 1915, p. 259.
[166] *Elek. Zeit.*, Mar. 25, 1915, p. 37.
[167] *Phys. Rev.*, Oct., 1914, p. 289.
[168] *Elec. World*, Jan. 9, 1915, p. 85.
[169] *Elec. World*, Jan. 16, 1915, p. 170.

A study[172] of the rotating sectored disk when used in photographic photometry has shown that an intermittent exposure, such as that given by the disk, has the same integral effect as a continuous exposure for the same period. The conclusion for ultra-violet radiation is the same as that found for visible radiation. Experiments were made on a variety of plates and it was found that the results were independent, within wide limits of the rate of rotation of the sector and of the period of exposure.

Gas-filled Tungsten Lamps. — The measurement of the candlepower of the gas-filled tungsten lamps has developed some entirely new problems in photometry. Thus it was early discovered[173] that both the watts consumed and the candlepower of the lamp vary when the lamp is rotated at different speeds. One set of experiments[174] showed that for any change in speed, while the change in candlepower was roughly ten times the change in current but always in the opposite direction, and regardless of the position of the lamp, the absolute change in candlepower with the lamp in the position of tip up is about twice the change with the tip down and similarly for the absolute change in the current. From the photometric standpoint a favourable condition was discovered in that for a given position of the lamp, the current and therefore the candlepower return to the stationary value at the same speed. If then, a gas-filled lamp is photometered in the position tip down, while rotating at the particular speed which gives the same current value as when the lamp is stationary the mean horizontal candlepower as measured will be free from errors due to rotation.

Various explanations have been offered for these phenomena. It has been suggested that they may be due to variations in the contacts between the filaments and the anchor wires ; to changes in the currents of gas about the filament ; to the lengthening of the helically coiled[175] filament, thus changing its resistance ; to a cooling effect due to the action of the external air in the bulb.

Photo-electric Cell.—In astronomical photometry[176] work is being done with some success, looking toward increasing the sensibility of the photo-electric cell. A null method of using photo-electric cells has been devised, which,[177] it is claimed, does away with the so-called " dark current " without in the least reducing the sensitivity.

Pentane Standard.—A redetermination at the National Physical Laboratory[178] of the constants of the Pentane lamp gave the following as the equation of the candlepower :

$$\text{C.P.} = ((1 + 0.0063\,(8 - e) - 0.0008_5\,(760 - b)$$

e being the humidity in litres of water vapour per cubic metre of moist air, and b the barometric pressure in millimetres. Evidence was obtained that there exists a temperature coefficient in the case of the pentane lamp, a point which had been raised previously at the Bureau of Standards. Apparently the temperature and humidity effects act against one another and in practice it is the difference between the two which is operative. It is suggested that if work of the very highest accuracy is to be carried out with flame standards under abnormal humidity conditions, the combined humidity temperature coefficient should be determined for the locality in which the work is to be conducted.

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[170] *Jour. of Frank. Inst.*, July, 1915, p. 102.
[171] TRANS. I. E. S., 9, 1914, p. 734.
[172] *Ann. d. Phys.*, Nov. 3, 1914, p. 801.
[173] TRANS. I. E. S., 9, 1914, p. 1024.
[174] *Elec. World*, Dec. 26, 1914, p. 1248.
[175] *Elec. World*, Jan. 9, 1915, p. 78.
[176] *Science*, June 4, 1915, p. 810.
[177] *Phys. Rev.*, July, 1915, p. 66.
[178] *Phil. Mag.*, July, 1915, p. 80.

Radiation.—Experiments[179] on the emissivity of metals at high temperatures have given results indicating a change in the emissivity of platinum for wavelength $\lambda = 0{\cdot}65\mu$. This fact if verified would influence the constancy of the Violle standard of light.

Two investigations have been made during the year on the determination of the visibility of radiant energy. One covered[180] the whole visible spectrum going further into the red and violet than heretofore. The other[181] dealt with the red end of the spectrum only, results being obtained out as far as $\lambda = 0{\cdot}770\mu$.

Calculation.—Methods of calculating the illumination produced by a direct-lighting source are numerous and well known. But in the case of a totally indirect or semi-indirect unit the calculation is decidedly modified. A method has been proposed[182] in which it is necessary to know only the photometric curve, the coefficient of reflection for the secondary source (usually the ceiling), the distance of the unit below the ceiling and the height of the ceiling above the plane of illumination. Roughly the method involves the consideration of the ceiling as a secondary light source considered as made up of a series of circular annuli or rings of uniform intensity of illumination. The effect of each ring is calculated independently.

Nomenclature.—Considerable attention has been given to the subject of nomenclature during the past year. It has been proposed[183] that the word " lambert " be used in referring to brightness in lumens per unit projected area. The " lambert " is interpreted as the equivalent in appearance to the eye of a surface source emitting one lumen per unit area in accordance with Lambert's cosine law. The following resolution which was submitted by the Committee on Nomenclature and Standards has been approved[184] by the Council of the Society :

Resolved, That it is the opinion of this Committee

(*a*) That the output of all illuminants should be expressed in lumens.

(*b*) That illuminants should be rated upon a lumen basis instead of a candle-power basis.

(*c*) That the specific output of electric lamps should be stated in lumens per watt and the specific output of illuminants dependent upon combustion should be stated in lumens per British thermal unit per hour.

Photography.

Sources.—The use of gas light[185] for taking pictures is increasing and special mantles have been designed for the purpose. In order to facilitate the use of the high intensity gas-filled tungsten lamp[186] in photographic portrait studios, a coloured glass screen has been developed which reduces the luminous intensity of the light to one-third its ordinary value without appreciably reducing the actinic value for ordinary plates. For convenience this glass has been incorporated in the lamp bulb. Thus high candlepower lamps may be used without producing an uncomfortable glare. It has been found possible[187] to use such lamps, screened as described, in moving picture production studios. In a big western moving picture plant[188] there is used a combination of mercury-vapour lamps and 2,000-candle-power tungsten gas-filled units of the type just mentioned. In Germany[189] tests have been made on the use of the gas-filled tungsten lamp for photographic work at voltages higher than normal, thus giving greater actinic value. This same idea has been proposed and experimented on[190] in this country.

Tests have been made on[191] the density of the photographic image produced under fixed conditions of distance and time by the light from different types of arc lamps under various conditions. The lamps tested were of the alternating current and direct current enclosed carbon and flaming arc types operated at various currents. The results showed that the highest actinic efficiency was obtained by the 220-volt, enclosed carbon arc ; next in value were respectively, the alternating current and direct current 110-volt, flaming arcs with electrodes designed particularly for photographic work.

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[179] *Phys. Rev.*, Dec., 1914, p. 547.
[180] *Phil. Mag.*, Feb., 1915, p. 301.
[181] *Phys. Rev.*, July, 1915, p. 68.
[182] *Elec. World*, June 5, 1915, p. 1463.
[183] *Elec. World*, Mar. 29, 1915, p. 715.
[184] TRANS. I. E. S., 9, p. 2, 1914.

[185] *Gas Age*, Mar. 15, 1915, p. 304.
Light. Jour. (U.S.), Dec., 1915, p. 281.
Proc. Amer. Gas Inst., vol. 9, 1914, p. 886.
[186] *Elec. World*, Nov. 14, 1914, p. 950.
[187] TRANS. I. E. S., No. 2, 1915, p. 166.
[188] *Elec. World*, July 17, 1915, p. 137.
[189] *Zeit. f. Beleu.*, Mar., 1915, p. 33.
[190] *Elec. World*, Nov. 14, 1914, p. 950.
[191] *Elec. World*, Nov. 14, 1914, p. 956.

A photographic paper has been developed[192] on which portraits may be reproduced directly without the preparation of the usual negative. For operation with artificial illuminants the paper is treated with a dye which makes it more sensitive to yellow light. The pictures are mirror images of the original.

Legislation.

Calorific Standard.—The Illinois Commission hac ruled[193] that in all parts of the state excepting Chicago a calorific standard of 565 B. t. u. for gas shall be used. Chicago is to remain under the candlepower standard. The calorific standard has been adopted by the Maryland Public Service Commission.[194] A heating value of 600 B. t. u. is specified. It was estimated by the Commission that in the state generally only 6 to 10 per cent. of the gas used is burned in flat flame burners. The use of the calorific standard in gas undertakings does not seem to be growing rapidly in England.[195] Only eight companies have applied for Parliamentary authority during the session of 1915. Four of these companies applied for a 500 B. t. u. standard.

Glare.—Extremely bright lamps are no longer allowed on residential streets, especially in front of isolated stores, in Washington, D.C.[196] Regulations adopted prohibit the use of lamps exceeding 100 candlepower on streets other than business streets. They also require a minimum height of 15 ft. (4·57 m.) for all private lamps supported from sidewalks, and that such lamps are to be enclosed in opalescent globes in order that the eyes of passers-by shall be protected from glare.

In December last[197] the War Department issued regulations ordering all fishing fields to be protected by a marine lantern of recent invention using acetylene as the illuminant. These lanterns, capable of 23 days' service, are arranged to give an in-shore and out-shore light to warn vessels that the areas thereabout comprise fishing pounds and are not open to navigation. Already a number of these lights have been placed.

A bill has been introduced[198] in the Utah legislature providing for the creation of special lighting improvement districts, under which the property owners on any street or sub-division may petition the city commission to create such districts and to install therein lighting systems.

Safety.—The Ottawa (Canada) City Council have recently[199] taken up the matter of all-night lighting of public buildings used for residence purposes. A by-law has been passed providing that the stairs, halls and corridors of all apartment houses, hotel and lodging houses must be lighted up from sunset to sunrise.

In places where public safety demands it there is a growing tendency on the part of municipal authorities to require two independent systems of illumination so that in cases of failures on the part of either the other will be available.

Headlights.—The Public Service Commission of Vermont has issued an order[200] concerning the use of headlights on locomotives. Railroad corporations doing business within the state are required to equip engines with headlights of not less than 2,500 apparent beam candlepower when measured with the aid of a reflector, rated in accordance with the average of the centre readings between 500 and 1,000 ft. (304·80 m.) ahead and upon a reference plane 3 ft. (0·91 m.) above the rails. In Nevada an amendment to the electric headlight law has been passed,[201] providing that any electric headlight " which will pick up and distinguish an object the size of a man dressed in dark clothing on a dark and clear night at 1,000 ft." will be deemed equivalent to a 1,500-candle-power headlight measured without reflector. Legislation regarding headlights for motor vehicles has also been passed in New Jersey.

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[192] *Elec. World*, Jan. 16, 1915, p. 190.

[193] *Proc. Amer. Gas Inst.*, vol. 9, 1914, p. 373.

[194] *Jour. of Gas Light.*, May 24, 1915, p. 463.

[195] *Amer. Gas Light Jour.*, Feb. 1, 1915,p. 73.

[196] *Elec. World*, Oct. 10, 1914, p. 700.

[197] *Acet. Jour.*, Feb., 1915, p. 305.

[198] *Elec. Rev. and W. E.*, Feb. 27, 1915, p. 376.

[199] *Elec. News* (Can.), Apr. 1, 1915, p. 38.

[200] *Railway Age Gazette*, Jan. 22, 1915, p. 127.

[201] *Railway Age Gazette*, Jan. 22, 1915, p. 123.

Illuminating Engineering in General.

Daylight Saving.—By adopting eastern standard time Cleveland, Ohio, has added one hour to the period of daylight. The result[202] has caused a renewed interest in the so-called "daylight saving movement" in the middle west. In Holland also this movement is being agitated.[203]

The use of light sources imitating daylight is growing[204] and has been found advantageous not only in clothing, painting and wall paper stores and factories, but also in printing and lithographing establishments, paper mills, oil refining plants, cigar factories, &c.

It has been proposed[205] to add to the numerous collections in Berlin a museum of illuminating appliances in which the development from the 17th century of lamps and other devices for street lighting will be shown.

Luminous Efficiency.—Values of the radiant luminous efficiencies (ratio of the energy radiated evaluated according to its effectiveness in producing the sensation of light to the total energy radiated) of various light sources have been determined using the method which employs an absorbing solution whose transmission curve is the same as the luminosity curve of the eye.[206] Among the results obtained were :—

4 w.p.c. carbon lamp	0.43
0.8-ampere Nernst filament	1.08
6.6-ampere gas-filled tungsten at 0.65 w.p.c.	2.93
Ordinary vacuum tungsten at 1 w.pc.	1.99
Open burner, gas	0.9
Incandescent mantle, gas	0.5 to 1.2
1.7 ampere mercury arc, Pfund type	30.0

A new experimental determination[207] by two different methods gives for the mechanical equivalent of light a mean value of 0·00162 watt per lumen.

Physiology.—Further work has been done on[208] the effect on the eye of ultra-violet light. It has been shown that where the protein in the lens of the eye has been modified by the action of excess sugar in the body fluids, or by the action of salts of calcium, magnesium, silica and the like, ultra-violet radiation may cause cataract, but that unless this abnormal condition exists cataract is not caused by this form of radiation.

Music and Colour.—Several attempts to correlate music and colour have been made in the past. A Russian composer having written a score in which was included a part to be rendered by various colours; a "colour organ" was devised for use in a recent presentation of the composition.[209] Incandescent lamps in reflectors and equipped with colour-filters formed the light source. The screen was composed of strips of gauze of various weights mounted vertically 8 by 10 ft. (2·43 by 3·04 m.) in size. The lightest sheet was placed at the front, each succeeding one back of it being heavier. The rear gauze was heavy enough to reflect the light thrown on it. The deepest colours were thrown on the back and the lighter colours were thrown on the front gauzes. The colour equivalents of the tone scale were as follows: C, red; D, yellow; E, pearly blue; A, green; B-flat, steely gray; together with intermediate values. Colour organs are not new,[210] several having been constructed in recent years. The largest screen used has been 30 by 50 ft. (9·14 by 15·24 m.).

International Commission.—At the meeting of the National Illumination Committee of Great Britain held early in the year[211] there was considered the question of "Rating of Light Sources in Candlepower or Consumption," and the following resolution was passed and transmitted to the Secretary of the

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[202] *Elec. Word*, Jan. 2, 1915, p. 59.

[203] *Jour. Gas Light.*, Jan. 5, 1915, p. 16.

[204] *Elec. Word*, July 10, 1915, p. 71.

[205] *Jour. Gas Light.*, May 4, 1915, p. 292.

[206] *Phys. Rev.*, Mar., 1915, p. 208.

[207] *Phys. Rev.*, Apr., 1915, p. 269.

[208] *Elec. World*, Apr. 19, 1915, p. 912.

[209] *Sci. Amer. Supp.*, June 26, 1915, p. 408.

[210] *Sci. Amer.*, July 24, 1915, p. 79.

[211] *Jour. Gas Light.*, Feb. 9, 1915, p. 326.

International Commission on Illumination.

It is desirable that a uniform international method be adopted for rating and marking all sources of light. It is recommended by the National Illuminating Committee of Great Britain that the matter be considered at the next session of the International Commission on Illumination; and the administration of that Commission is asked to take the necessary steps to bring this resolution to the knowledge of the different national committees, with the view to their co-operation.

Literature.

The war has seriously interfered with many foreign publications having articles on illumination. The French Journal, *Science et Art de l'Eclairage*, has apparently suspended publication and other French and German journals were compelled to omit some issues although they are now appearing regularly. Among the books published during the year should be mentioned :—

Modern Illuminants and Illuminating Engineering, by L. Gaster and J. S. Dow. New York, The MacMillan Co., 1915.

La Lumiere Electrique et ses DifferentesApplications du Theatre, by V. Trundelle. Paris, H. Dunod and E. Pinat.

An Introduction to Colour Vision, by Dr. J. H. Parsons. Cambridge University Press, 1915.

ILLUMINATION OF TROLLEY-WIRES.

AN interesting example of the special problems in street-lighting occasioned by the present conditions is to be seen on the tramway at those points in London where there is a transition from the slot to the trolley-wire system. The driver in such cases has to unfasten the trolley pole and connect with the line overhead. On nights when there is a moon, and the pole and wire can be seen silhouetted against the sky, there is little difficulty. But on dark nights, with the present diminished artificial illumination, the process became distinctly awkward. The wire cannot be clearly seen, and passengers would have to endure a period of constant flickering while the pole scraped the wire, missed, and hit it again.

The difficulty is now got over by the use of a flat dish-reflector containing a lamp and attached to the supporting lines above the live wire. The illuminated surface of this reflector affords the necessary bright background, and is so constructed that no direct rays can be seen from above.

NATIONAL PHYSICAL LABORATORY.

REPORT FOR YEAR 1915—1916.

The Report of the National Physical Laboratory for the year 1915—1916 has now appeared.

As might have been expected, the ordinary work of the Laboratory has been largely set aside in favour of special researches undertaken for Government Departments. For example in the section of optics, the staff have been engaged in the testing of binoculars, telescopes and other optical "munitions of war," and special researches have been made on the intensity and duration of light yielded from luminous paints Very important work has also been conducted in the department of aeronautics.

We are glad to see that the generosity of private benefactors has to a great extent made good the deficit in fees ordinarily received for industrial work, and hope that after the war the Laboratory will be placed in a position to carry on its valuable researches on a much more extensive scale.

AT a meeting of Liverpool business men at St. George's Hall, on Empire Day, organised by the British Electrical and Allied Manufacturers' Association and presided over by the Lord Mayor, the following resolution was passed :—

"That the indispensable military services rendered by the engineering industry and its fundamental importance in the future as the basis of defensive power and of prosperous economic development, entitle it to special State recognition in any reform of national and imperial commercial policy, and to the patriotic support of all public and private users of plant and machinery throughout the Empire."

THE LIGHTING OF ARMY HUTS.

We recently heard of a large camp of Army huts, which were being lighted by gas, and where the question of the best method of illumination was under discussion. Hitherto the huts have been lighted in the ordinary way by incandescent units, but the hard usage to which the lamps have been subjected makes the question of maintenance rather troublesome. For example, the men are apt to throw their caps and other missiles about, occasionally striking the lamps—treatment which even the best of mantles, unless specially protected, will resent.

It has therefore been suggested that flat flame burners should be used. This seems a retrograde step, especially in view of the probable diminution in the illuminating power of the gas, just now owing to the withdrawal of constituents wanted for munition work. A preferable step would probably be to substitute mantles enclosed in "binnacle-lights," which are mounted direct on the wall and are capable of withstanding any reasonable amount of shock. The introduction of these units would involve some initial expense, but would doubtless be justified by the results as regards illumination and maintenance.

A similar problem arises in connection with the use of electric incandescent lamps. While large mess-tents, etc., where the lights are quite out of reach, may be illuminated by pendant units, it would seem desirable to avoid pendants altogether in the smaller rooms and to mount the lamps direct on the ceiling. A simple form of metal reflector is also useful, both as a protection and with a view to concentrating the light downwards. In this case also there seems an opening for a cheap type of completely enclosed unit, similar to those used on board ship.

REFINEMENTS IN ILLUMINATION.

In a recent article in the *Electrical Review* it is remarked that there are still endless opportunities for ingenuity in meeting special problems and opening new fields of lighting.

As an instance reference is made to the lighting of pulpits in churches. It is generally recognised that the lamp should be screened and that the direct rays should on no account be allowed to stray into the eyes of the congregation. The design of the most convenient form of reading lamp, at a convenient height to illuminate the desk evenly and yet not to obstruct the congregation's view of the preacher, is, however, worth attention. In addition, it is questionable whether such shaded lights should throw light on the book only, leaving the preacher's face in shadow. A congregation likes to see the face of the preacher. A special case is presented in churches ministering to the deaf, and the same problem recurs in all buildings where training of the deaf is carried on. In such cases the preacher's meaning is interpreted by observing the motions of the lips and the face generally, and the facility with which this can be done depends very much on the provision of an adequate illumination. Indeed, people who are only slightly deaf, or even people who have normal hearing, really derive appreciable assistance from the observation of the face of the person with whom they are conversing.

Another special opportunity for skill in illumination is to be found in art museum-lighting. The possibilities of special units, both for displaying exhibits and as a decorative element in themselves, have hardly been explored as yet. For example, the problem of artificially illuminating precious and perishable articles in showcases, so as to show off their outline and colour to the best advantage, and also to preserve them as far as possible from colour-depreciation through the action of the short waves of light, is well worth study.

CORRESPONDENCE.

"CELL-PHOTOMETERS."

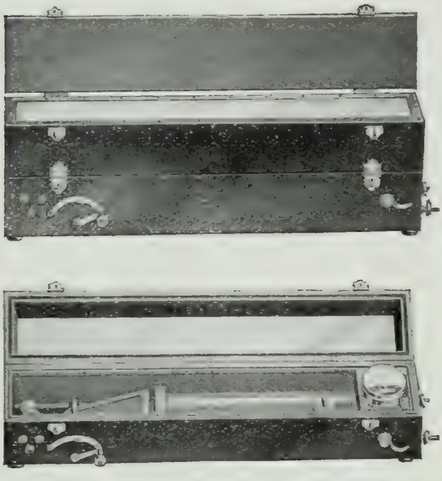
To the Editor of the Illuminating Engineer.

Dear Sir,

I have read in the March issue of the Illuminating Engineer the very interesting descriptions of the "cell type" and "graded scale type" photometers by Mr. Cunnington and Mr. Dow.

It occurs to me to mention that photometers on the same principle were constructed by Mr. Kovalen, chief engineer to one of the electric supply stations in Petrograd, about the year 1906.

In this instrument he employed an opal glass screen illuminated from below by a low voltage (4.5 v.) lamp, fed from a storage battery. This screen formed the cover of a long black box, the lamp being mounted at one end, on the bottom of the box. The upper surface of the glass screen is painted dead white but there is a narrow slit left in the middle, which runs the full length of the screen. This screen is covered by a thin plate of ground glass, which carries an appropriate scale.



General view of Kovalen's Box Photometer (enabling illumination to be determined by inspection without manipulation of parts).

When the lamp is switched on we see at one end of the screen a dark slot with white surroundings, and at the other end the converse effect, the point of balance, indicating the illumination, being intermediate. There is no difficulty in ascertaining the point of balance and reading off the corresponding value in lux. The range of this instrument is normally 0.2—60 lux but it can be extended if desired. The box carries a rheostat and a voltmeter reading up to 6 v. and also an adjustable glass screen for diminishing the illumination of the slit and thus extending the range of the instrument, if required.

The general nature of the instrument is shown in the accompanying photographs. The precision of measurement is naturally not so high as in the case of apparatus of a more elaborate type, but the convenience of being able to make a rapid estimate of the illumination on a large surface is very useful for some classes of work.

Yours, &c., S. Maisel
(Physical Laboratory, Institute of Mines, Petrograd).

A POCKET LAMP WITHOUT BATTERY.

The *Elektrotechnische Zeitschrift* (Feb. 24th) describes a novel form of pocket lamp that has been devised by K. v. Dreger of Budapest. This contains a small glowlamp which is fed, not by accumulators or dry cells, but by a small hand-operated dynamo. The novelty of the arrangement appears to consist mainly in the ingenuity of the mechanism by which this is driven. If the lamp is held in one hand a slight motion of the thumb suffices to keep the dynamo in motion, and it is stated that even after the latter is removed the dynamo will continue to revolve long enough to give a light for several minutes.

THE PHOTOMETRY OF GAS-FILLED LAMPS.*

The photometry of gas-filled lamps presents quite a number of special difficulties.

On account of the comparative broadness of the filament spiral and the dissymmetry of the filament mounting there is considerable irregularity in the distribution of the light about the vertical axis. Consequently when the lamp is rotated the light as seen in the photometer appears to flicker so much as to render accurate photometry impossible. This difficulty may be largely eliminated by using two inclined mirrors behind the lamp.

There is, however, a more serious difficulty, namely, that rotation alters the current consumed and the resultant candlepower. The change in efficiency may be either positive or negative according to the speed of rotation, and there appears to be one particular speed at which correct results may be obtained; this speed is practically the same for all lamps having the same number of loops in the filament. If this precaution in selecting the correct speed is not observed, errors of 1 to 2 per cent. in current and 15—20 per cent. in candlepower may be encountered. Hence the voltage found for a desired operating efficiency may be so much in error as to give a lamp on test at this rated voltage a fictitious life three or four times as long as the lamp would give if operated stationary. The lamp may thus be given credit for a much longer life than it really deserves. On the other hand, the speed may be such as to cause errors in the opposite direction.

These changes during rotation appear to be due to alterations in the convection currents of the gas, with a consequent variation in temperature distribution within the bulb.

Another point to be noted is that the blackening of a gas-filled lamp does not occur uniformly over the bulb as is the case with a vacuum lamp, but chiefly at the top of the bulb. Hence in making a life test, a true measure of the reduction in total light during the life of the lamp can only be determined by measurement of the total flux or mean spherical candlepower. This is most conveniently determined in the Ulbricht globe.

A NEW ILLUMINATION-INDICATOR REQUIRING NO MANIPULATION.

We notice that the type of instrument described in Mr. Maisel's letter in this issue (p. 262) is being developed in the United States. Such an instrument has been described by Mr. R. F. Pierce.* In this apparatus, which reads from 0·1 to 50 ft.-candles, there is also a slot along which the point of balance moves according to the illumination, but readings are facilitated by a series of disc-apertures at intervals, and the range is extended by using a second slot equipped with an interior dark covering reducing the brightness to 1/10th.

The simplicity of this type of instrument is a recommendation in cases where only rough indications of the illumination are needed; but one point, mentioned by Mr. Pierce, requires attention, namely, that the indication varies somewhat according to the angle from which the surface is viewed. A small sighting arrangement is therefore provided to secure that the angle of vision is always the same.

PROGRESS OF THE BRITISH RARE-EARTH INDUSTRY.

A paper on this subject was presented by Mr. S. Y. Johnstone at the Annual Meeting of the Society of Chemical Industry, held in Edinburgh last July. It was computed that the number of mantles used in the United Kingdom during a normal year is about 100,000,000, which would correspond with an annual consumption of 650 tons of Travancore monozite sand. In the past this country has had to depend very largely on imported mantles, and although manufacturers have developed their output very rapidly since the outbreak of war, there is evidently still a great deal to be done before they will be able to supply the entire needs of the country.

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* *Photometry of the Gas-filled Lamp*, by G. W. Middlekauff and J. O. Skogland (Bull. Bureau of Standards, Washington, No. 264, March 16, 1916.)

* *Am. Gaslight Journal*, Aug. 14, 1916.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

SOUTH METROPOLITAN GAS CO.

Half-Yearly General Meeting.

At the half-yearly general meeting of the South Metropolitan Gas Company on August 9th an interesting address was given by the Chairman (Mr. Charles Carpenter, D.Sc.), who explained the circumstances that had enabled the company to reduce the price of gas by 2d. per 1,000 cub. ft. An encouraging fact was the maintenance of the consumption of gas at slightly above the figure at which it stood previous to the war. There had been considerable diminutions in the amount of gas used for certain purposes, *e.g.*, for domestic uses and shop lighting, but, on the other hand, there had been an increased industrial demand.

Turning to the question of residual products and their paramount importance for war, the Chairman remarked that in future matters would have to be so organised that these essential materials could be obtained from the gas companies at short notice. The coal resources of the country would be dealt with in a less wasteful manner, the ammonia, light oil, benzol, etc., being removed, and the gas companies would probably be much larger suppliers of solid fuel than had hitherto been the case.

In this connection the Chairman made an interesting remark regarding the future co-operation of gas and electrical supply "I do not know," he said, "whether the policy adopted by Parliament of putting the suppliers of gas and electric energy into competition, has not had its day; it may have. If one were to begin again, one would not do what one is doing to-day, viz., put up a large station to produce electric energy and another for gaseous energy. We should look to see whether these supplies should be undertaken separately or whether there was not a great deal to be said on the point of economical working by running them together."

HOLOPHANE INDUSTRIAL LIGHTING UNITS.

We understand that a new edition is to be issued shortly of the booklet describing the Holophane units for Industrial Lighting. In these units the external surfaces of the prisms are completely protected against any possible deposits of dust and dirt by a coating of aluminium, and at the same time the reflecting value of the prisms is fully maintained. We are informed that these units are being extensively introduced into munition factories, but at the present time it is naturally impossible to say much on this matter.

The convenient tables given in the booklet, showing the illumination derived from units hung at any prescribed height, are retained in the new edition, but several modifications are made rendering them better adapted to practical use. Other features are the introduction of a series of units of the well-known Bowl and Excellite types for providing diffused semi-indirect lighting in offices and some simple iron fittings which are applicable both to office and industrial lighting.

THE "LISTER-BRUSTON" AUTOMATIC ELECTRIC LIGHTING AND POWER SYSTEM.

Electric lighting for country houses has passed through some interesting series of stages of development. The coming of the metal filament lamp proved a great godsend, diminishing the capacity of plant required for a given number of lights and furnishing a much more efficient illuminant than the old carbon filament lamp. A difficulty, however, has always been the necessity of providing a battery of accumulators, the upkeep and maintenance of which is often not fully understood or sufficiently appreciated by the consumer.

An interesting method of dealing with this problem is furnished by the Lister-Bruston system of lighting, which is essentially automatic. The current is supplied by a dynamo driven by a small petrol-engine, but only a few accumulators (of a specially strong type) sufficient to feed three or four lamps, are used.

If only a few lights are in use, the current is supplied by the accumulators. When, however, more lights are turned on, the extra current operates an automatic switch, causing the current from the cells to be delivered to the dynamo which rotates for a few seconds as an electric motor, thus starting the engine. From this point onwards the main load is taken by the dynamo. When the number of the lights is diminished a converse operation takes place, the dynamo and engine being automatically taken out of circuit as soon as only a few lamps are connected, leaving these supplied by the accumulators. The great advantage of this system is that the number of cells required is small and the loss involved in the charging and discharging of a battery sufficient to supply the entire lighting load is avoided. Moreover, as there are only a few cells of a robust type to look after, the expenses of maintenance are reduced to a minimum ; in addition, the cells are automatically kept charged by the action of the dynamo, thus working under satisfactory conditions.

In the case of large installations, or for the lighting of a group of houses or a village, the plant is preferably subdivided. It can be so arranged that a light load starts up only one of the units, others being automatically switched into circuit as the load increases ; and, conversely, cut out of circuit again as fewer lights are required. In this way the plant is always operated at a good efficiency.

As an instance of such an installation we may mention the recent lighting of the town of Seward, Albany, U.S.A., for the Seward Lighting and Power Co. We understand that the equipment, which consists of two Lister-Bruston Town Lighting sets complete, with a 300-ampere-hour battery, is worked entirely automatically, each of the sets starting and stopping as and when the external load demands. The total output of the station is about 20 k.w.

The speed with which this installation was carried out appears remarkable, the franchise being obtained, power-house built, mains run in streets, and the plant in full operation within six weeks.

We are also glad to note that the question of the best use of the lighting provided is not overlooked, and that the staff of Messrs. R. A. Lister and Co., 47, Victoria Street, London, S.W., are prepared to give advice as to the best schemes of lighting for buildings of all kinds.

REVIEWS OF BOOKS.

Colour and its Applications, by M. Luckiesh. (*Constable and Co., London,* 1915. 357 *pp.* 129 *illustrations,* 4 *colour plates.*)

Mr. Luckiesh's work on colour is well known to readers of this journal, and his collection of the ideas that have recently been developed on this subject makes a most readable book. Probably the work will be chiefly useful to those who have kept in touch with illuminating engineering work during the last few years, but even those who have little expert knowledge of colour will appreciate his lucid treatment of this fascinating but highly complicated subject.

The initial chapters deal with fundamental principles. The author explains briefly the conception of light as a form of radiation, and traces the physiological factors involved in the subjective translation of this radiation into the impressions of light and colour. The distribution of energy throughout the spectra of the chief illuminants is illustrated by appropriate diagrams, the luminosity curves for the human eye at high and low illuminations are reproduced, and photographs of typical spectra are presented. The chapter on colour-mixture is illustrated by a coloured diagram showing the difference between additive and subtractive methods. The author comments on the need for some generally accepted method of colour definition, making effective use of a quotation from a letter from Robert Louis Stevenson bearing on this point. The chapter on the analysis of colour contains a series of diagrams of modern spectroscopes and spectrophotometers and the discussion on colour and vision is thoroughly up to date.

Of special interest are the tests carried out by the German Lighthouse Board of Hamburg on the visibility of signal lights. The agreement of these results with the more recent experiments of Paterson and Dudding at Teddington appears remarkably good, and formulæ connecting candle-power and range are suggested. The latter are, however, complicated by questions of colour. Reference is also made to the value of monochromatic light in enhancing acuteness of vision, and to the presumed advantages of using yellow light from which the blue and violet rays are excluded for searchlights. Yellow and fluorescent glass screens have been proposed for this purpose with a view to avoiding the " luminous blue haze " and improving definition.

Chapters are devoted to colour photometry and colour photography, and there is also a brief account of theories of colour vision.

The final section of the book, dealing with colour in lighting, contains much interesting matter. The author summarises the various attempts that have been made to secure " artificial daylight " for colour-matching work. The effect of different illuminants on the appearance of colours is illustrated by several coloured plates contrasting the appearance of pictures by natural and artificial light. This point is further explained by means of black and white reproductions showing how, by using light of a special colour, certain features in a picture may be made to disappear. This effect has been utilised in practice in illuminated signs, wherein certain words and phrases may be made to vanish by an alteration in the quality of the illumination. In a less marked degree these effects manifest themselves in many interiors, in which varied coloured wallpapers, borders and designs are employed.

Mention should next be made of Mr. Luckiesh's treatment of the subject of "mobile colour" as utilised in various devices for stage illumination. Here there are many as yet imperfectly explored possibilities. The idea of using colour-harmonies as alternative or supplementary to musical sounds is exemplified in the Rimington colour-organ, and in the devices employed by the composer Scriabine, who added to his orchestral score an accompaniment in which colour changes were specified as an accessory to the music. The mere fact that phrases descriptive of colour occur so frequently in musical criticism shows the existence of such an analogy, and it is conceivable that in the art of the future colour harmonies will play a more important role than at present.

The author's practice of recording a complete list of references at the end of each chapter will be a recommendation to those who have not yet gone deeply into this subject. A word of commendation should also be given to the excellent printing, mat paper without glaze being used throughout both for the text and the illustrations.

A Statistical Report of Electric Undertakings in Japan (1914), *issued by the Direction General of Electric Exploitations, Department of Communications, Tokyo, Japan.*

A correspondent in Japan sends us the above Statistical Report of electrical undertakings in that country, which, in view of the rapid industrial progress which Japan is now making, deserves careful study.

The first electrical undertaking was opened in Tokyo in 1887, one 75-h.p. dynamo being originally installed. Since then the various undertakings throughout the country have spread and developed, until to-day they produce millions of horse-power, a feature being the use of Japan's abundant water-power and of high tension transmission.

The Report is concluded by some interesting information covering the period 1903—1914. We notice that the total candlepower of lamps supplied has grown from approximately 4½ million to over 70 million during this period. Moreover, the rate of increase is still very rapid, being as much as 25 per cent. during the year 1914, while the extension of electric lines laid down for all purposes has taken place even more quickly.

The Development of Electric Lighting in Japan.

We have received from the Tokyo Electric Co. a most interesting booklet tracing the development of electric lighting in Japan. Starting from the most primitive rush-lights, braziers and torches, illustrated by characteristically quaint Japanese prints, the book carries us through the stages of lighting by candles, oil lamps, and lanterns, &c., up to the illuminants of the present day. Many of the early designs of candle-sticks and lanterns are decidedly quaint or beautiful, and present a complete contrast with our highly utilitarian modern methods.

If one may judge from the illustrations, however, it would seem that electric lighting fittings are being adapted with little change from the designs usual in the West. While it cannot be doubted that in the East, as in the West, modern methods of illumination are inevitable and essential, yet one may venture to hope that the characteristic charm of the older illuminants will not be lost. Engineers and artists in Japan will, we hope, exercise their ingenuity in grafting the new on to the old, providing the higher standard of illumination entailed in modern progress, and yet preserving some of the quaint and picturesque simplicity of times gone by.

The Excess Profits Duty and Profits of Controlled Establishments, by E. A. Spicer and E. C. Pegler, Chartered Accountants. (*H. Foulks Lynch and Co.*, 61, *Watling Street, London.* 1916. 163 *pp.*)

At the present moment there are few businesses which are not to some extent concerned with the Excess Profits Duty. While the principles involved are simple, the applications of the Excess Profits Duty to different classes of business are somewhat complex, and the above little volume should therefore be welcome.

The book is divided into five chapters, dealing respectively with the Excess Profits Duty, the Computation of Profits, the Pre-War Standard of Profits, Capital, and the Profits of Controlled Establishments. There are also an Appendix in which the section of the Act dealing with Excess Profits is reproduced, and a convenient Index. There is a concise summary of contents at the head of each chapter.

Paint and Colour Mixing, by A. S. Jennings. (E. and F. N. Spon, Ltd., London, S.W., 1915. 245 *pp. Seventeen coloured plates.)*

READERS of this journal are naturally interested in the question of colour, which is of importance in many lighting problems, especially in trades where accurate matching of shades is essential. This book, which summarises present practice in regard to paint and colour mixing, is therefore well worth study. The initial chapters contain an account of appliances for mixing and applying colours, and an explanation of the distinction between various oil and water paints, distempers, and special surfaces. There are also sections dealing with the chief colours in succession, and a feature is the series of coloured plates, containing, it is stated over 300 samples of actual oil- and water-paints and water-colours.

The chapter on nomenclature is of considerable interest. The author mentions several independent attempts to prepare a series of standard colours, for example, that due to Mr. Robert Ridgway, Curator of the Division of Birds, United States National Museum, Washington, and the excellent series of plates furnished in the "Repertoire de Couleurs par la Société Francaise des Chrysanthemistes." The systems of nomenclature adopted by those interested in different processes of colour-matching, *e.g.*, artists, flower florists, painters, dyers, &c., differ very considerably ; even in the same trade surprising variations in the names assigned to colours seem to prevail. Evidently there is room for an attempt to frame a general scientific method of nomenclature.

Another matter is the matching of colours by various lights. The author refers to the need for using a good north daylight for accurate work, but he does not appear to deal with matching by artificial light in any detail. In a future edition it would be interesting to include some mention of the various forms of "artificial daylight" now available, and to discuss their practicability for colour-matching processes.

PERSONAL.

We are informed that Mr. S. R. Mullard, of the Research Laboratory of the Edison and Swan United Electric Light Co., Ltd., has been granted a temporary commission as Lieut. R.N.V.R., attached to the R.N.A.S. We understand that Lieut. Mullard is being retained by the Ediswan Co., which will enable him to keep in touch with his laboratory work.

We learn with great regret of the loss of Company-Sergeant Major E. C. Laughton, who for nine years was associated with the Lamp and Fittings Dept. of Messrs. Siemens Bros. Dynamo Works, Ltd., and was a member of the Illuminating Engineering Society. He joined the Forces in September, 1914, and fell during the recent offensive in France, after 14 months' active service. Besides showing considerable business aptitude, his genial disposition gained him many friends in the electrical industry, and his loss will be widely regretted.

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Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

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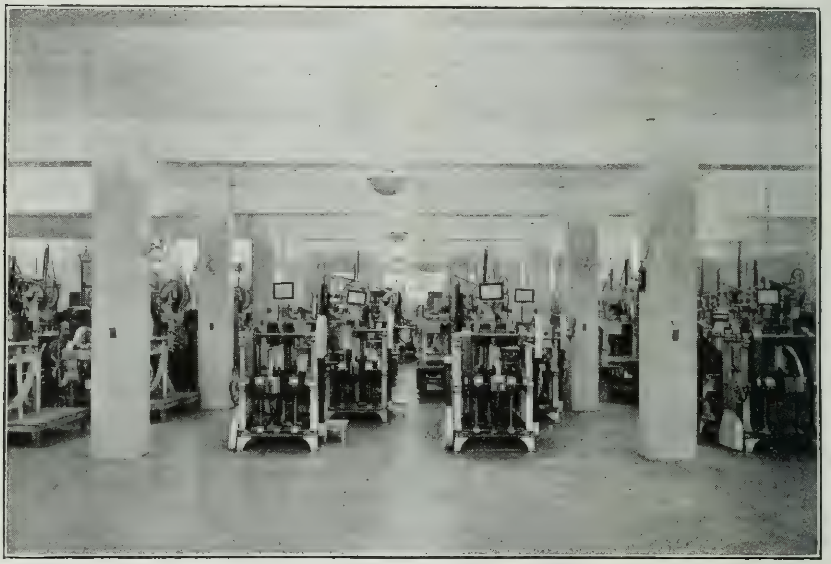
This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

AN INDUSTRIAL INDIRECT LIGHTING INSTALLATION.

In view of the general impression that indirect lighting is somewhat limited in scope for industrial lighting, the accompanying illustration, for which we are indebted to the National X-Ray Reflector Co. of Chicago, is of interest.

The photograph refers to the Packing Dept. of one of the factories of the Kellogg Toasted Corn Flake Co. (Battle Creek, Michigan, U.S.A.), and is typical of the modern type of factory building now being constructed in the United States, for which reinforced concrete is largely used. The walls and ceilings are finished in white and the floors are of natural concrete. In these circumstances a considerable amount of diffused reflection is obtained, so that the conditions are favourable to indirect lighting.



The factory is divided into bays 13 ft. by 20 ft., making an area of 260 square feet for each bay. At the centre of each bay is suspended an indirect "X-ray" fitting with 300 watt lamp. The fixture is also finished in white and is washable.

The machines seen in the foreground fold the cardboard boxes in which the corn flakes are afterwards deposited. For such work well-diffused illumination is necessary and we understand that the indirect system has given satisfactory results.

We may mention that the British Thomson-Houston Co., Ltd., are sole British agents for all X-ray specialities.

AN ECONOMICAL NIGHT-LIGHT.

The need for low candlepower electrical units to serve as night-lights and for use in cellars, passages, &c., is well recognised. On D.C. circuits it is not very convenient to obtain a sufficiently low consumption unit, although various devices, such as the use of dimming switches, or of double filament lamps, have been used.

On alternating circuits the problem is easily solved by using a low candlepower metal filament lamp operated from a transformer. The "All-nite-lite" supplied by the British Thomson-Houston Co., Ltd., employs this method, a lamp giving 3—4 candles being mounted direct on a small transformer so that the whole can be conveniently inserted into a standard lamp socket. Where alternating current is available this little unit should be quite useful.

ELECTRICITY · ACETYLENE · OIL · GAS

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LEON GASTER

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EDITORIAL.

Scientific and Industrial Research.

The Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research has just issued their first Report for the year 1915—1916, a summary of which will be found on pp. 277-280 in the present number.

The work of the Committee has been entered upon in somewhat difficult circumstances. Most of our industries are disturbed by the war, and the energies of skilled workers have been diverted into other directions. The Universities, too, have been largely depleted of their staff and students and, to quote the Report, " those who remain can command neither the leisure nor the detachment of spirit that are essential conditions for original research."

In these circumstances it may be asked " Why try to make a start now? Why not wait until the war is over and normal industrial conditions return? " The Report answers this objection by pointing out that the machinery for research cannot be improvised at a moment's notice. When hostilities cease there will doubtless be a period of adjustment and reconstruction, and our industries will then be in urgent need of guidance and assistance. The Council, therefore, wisely determined to make a commencement, to feel their way steadily but surely for the present, and to construct connections and machinery which will be capable of expansion and wider application in the future.

In many directions, *e.g.*, in connection with metallurgy, pottery, dyestuffs, optical glass, etc., work has already been done. There are naturally many details of organisation that require study. One interesting point is the respective spheres of action of Universities and highly specialised research institutions. The primary function of the University is admittedly to foster pure scientific research, on the continuity of which industrial progress ultimately depends. Yet it is desirable that Universities should also carry on a certain amount of research of direct industrial application ; otherwise they are apt to get out of touch with the industrial world, the process of conversion of pure science into applied science may be checked, and the channel of communication between the scientist and the manufacturer impeded. There are, however, highly technical industrial experiments which require to be carried on continuously for long periods, with the researcher in constant touch with the industry concerned, and in these cases highly specialised research institutions may be needed.

Speaking generally, results of great commercial importance are obtained as a rule after continuous research over a number of years. The conception that research must be made to pay its way within a limited period would be fatal to such work, and this is one reason for advocating that such experiments should be undertaken with the support of a whole industry, which can afford to bear the expenditure and await results, which an individual manufacturer frequently cannot do.

One of the most encouraging facts recorded in the Report is the readiness of professional institutions, Universities, and trade associations approached by the Council to co-operate in the initiation of researches of common benefit. This is a hopeful sign for the future.

An obstacle to the progress of industrial research is the fact that at present few manufacturers have received a scientific training, and men in charge of highly technical and essentially scientific industries are often unable to appreciate the nature of research or the conditions essential to its successful application. In some cases fear of the uncertain future operates as a deterrent. But whatever the future may have in store it seems certain that we can only compete successfully with other countries if our organisation and scientific training are at least equal to theirs. This is particularly true of the important " key-industries."

In this connection it is remarked :—" A healthy condition of such industries can only be secured if, for some time to come, a good deal of attention and money are expended upon convincing the manufacturer that scientific research is a paying proposition."

The immediate problem before us is therefore the exercise of a steady educational influence in favour of scientific and industrial research. This is work that can and should be done *now* as a preliminary to action in the future. We should like to recall one important channel of influence—of which we have every season to believe that the Advisory Council is well aware, although it is not specifically mentioned in the Report—the scientific and technical press. The two Resolutions recently passed at a meeting of the Circle of Scientific Technical and Trade Journalists put on record their willingness to co-operate in this direction, and there can be no doubt that they are in a position to do good service by acting as a channel of information to the respective industries with which they are connected. If, therefore, the Advisory Council will seek the co-operation of such journals and arrange an organised effort in the desired direction the seed of future progress would be sown, and the ground prepared now for the far-reaching measures which will doubtless be taken in the future.

Illumination in the Navy.

The lighting of battleships and the many ingenious applications of light and optics in naval gunnery, searchlights, and other special directions, is a most fascinating field for study. At present it is naturally impossible to discuss in detail such applications in the British Navy, although we hope that after the war it will be possible to say more on this subject.

Meantime we notice that in the United States naval matters are being keenly discussed, especially in their engineering aspects, an instance being the paper by Lieut. C. S. McDowell on " Illumination in the Navy," which is referred to on pp. 281—283 in this issue. The " battle " and " lighting " circuits on American warships, he states, are supplemented by a special emergency circuit, and it is evident that the entire interruption of the lighting of a ship in action would often be a serious matter. Every effort is therefore made for the duplication and protection of circuits. It is interesting to note that as far back as 1912 the Navy Department initiated a special investigation into the conditions of illumination on warships, as a result of which a table of the illumination-intensities in foot-candles in various departments was drawn up. In view of the fact that life on board shiy takes place so largely under cover, where there is little, if any, access of daylight, it seems very desirable to fix a reasonable standard for the artificial illumination.

The design and use of searchlights, and the application of light for signalling purposes are also discussed in Lieut. McDowell's paper. Experiments on cooled electrodes, run at a very high current density, have now been made in the United States, and it is stated that the candlepower and concentration of beam of the Beck searchlight have been equalled and even surpassed. Good progress has also been made with projectors of moderate power, using concentrated incandescent filaments. The highly debateable question of the effect of colour of the beam is also discussed. There is a general impression that the use of gold-mirrors, or yellow transparent diaphragms, in order to exclude the blue and violet light, is advantageous, but the question cannot be regarded as finally settled.

Lieut. McDowell's paper suggests that the United States Navy is keenly alert to the necessity of being kept informed of the latest advances in illumination. For some time a movement has been in progress for organising the scientific and engineering resources of the country for naval work. We notice, for example, an address by Mr. Frank P. Sprague, a member of the Naval Consulting Board of the United States on " Naval Preparedness and the Civilian Engineer."*

Mr. Sprague gives some interesting particulars of the work of the Naval Consulting Board, which was formed by the appointment of two representatives by each of the leading scientific and engineering bodies in that country. The Board has already recommended the erection and equipment of a Naval Research Laboratory and Experimental Station, at a cost of about one million pounds, with an annual expenditure on experimental work of about half a million pounds.

It is significant that one of the first steps taken by the United States in the direction of " Preparedness " should be in the direction of organising scientific research. No doubt this matter is receiving attention from the Authorities in this country.

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* Jour. of the Western Society of Engineers, Feb. 1916.

Hours of Labour.

It will be recalled that in a recent Memorandum issued by the Committee of the Ministry of Munitions (No. 5) some general recommendations were made as to the limitation of hours of work. Since that time detailed inquiries into various kinds of work have been made, and a striking Report on the subject by Dr. H. M. Vernon, whose services were secured by the Medical Research Committee, has just been issued.

It was previously suggested that the average weekly hours of labour, including overtime, should not exceed 65—67 for men, and 60 hours for women. Naturally such figures may require a little modification according to the kind of work done, and in Dr. Vernon's researches a broad distinction has been drawn between heavy, moderately heavy, and light labour.

The results confirm the previous recommendations in a most remarkable manner. Indeed, in many cases the hours might with benefit apparently be reduced below the figures quoted above. There is clear indication of the benefit of a short holiday. By tabulating the hours of work, hourly output, and the produce of these two quantities over a period of several months, it was often possible to establish that longer hours meant, in the long run, a smaller output. Thus in the case of 100 women turning fuse-bodies, it was shown that a diminution in working hours from 68·2 to 59·7 hours per week was coincident with a gain in total output of 8 per cent. In the case of a group of youths of 14—17 years of age, also working on fuse-bodies, an even more remarkable result is recorded. It was found that after the Christmas holiday the hourly output rose to 16 per cent. greater than in the pre-Christmas period, in spite of slightly longer hours, whilst it was no less than 42 per cent. greater in the eleven subsequent weeks, when the weekly hours of labour were reduced from 70·3 to 57·0; in consequence the total output attained a value 19 per cent. in excess of that before Christmas. These boys were evidently overworked by the long hours, and the reduction from 12 to 8 hours had an immediate beneficial influence.

Such cases prove the desirability of a careful scientific study of hours of labour in the interests of production, quite apart from their influence on the future health and well being of workers. It is to be noted that, in view of the present emergency the hours suggested are the *maximum* hours of work from the point of view of production; they are probably only possible for the fittest of the workers, and much in advance of the number of hours which would be considered best in time of peace.

Another point that deserves fuller study is the effect of a short recuperatory pause during the day. If workers are left to themselves they take rests at irregular and often unsuitable times. It would be much better to arrange for regular pauses at intervals, which will naturally vary with the class of work, and can only be determined by experiment. In many works there is a needless loss of time in starting and ceasing work, and if this could be avoided the time thus gained might well be utilised for rest purposes at convenient intervals.

In this connection the proper heating and ventilation of a factory is a most important matter. In order to raise the temperature of a large room to a comfortable value, the heating arrangements should be put into operation for a suitable period before the actual start of work. Otherwise time will inevitably be lost because the operators are physically incapable of giving the full output during the initial hours of work.

LEON GASTER.

PROGRESS IN NATURAL SCHOOL LIGHTING.

In a recent number of *School Hygiene*,* Mr. G. H. Widdows, F.R.I.B.A., gives an account of a most interesting "open air" school at North Wingfield (Derbyshire), the building of which was specially designed by him to meet the requirements of adequate ventilation, heating and lighting. The school has been running for nearly eighteen months. Through the courtesy of the Derbyshire Education Committee it was inspected when in course of erection by the Joint Committee of the Illuminating Engineering Society appointed in 1913 to consider Natural Lighting in Schools. Mr. Widdows expresses appreciation of the work of the Illuminating Engineering Society on this complex subject—work which, but for the interruption caused by the outbreak of war shortly after the issue of the Committee's report, would doubtless have received much more attention.

The arrangements at the North Wingfield School in respect of lighting, heating and ventilation are, in some respects, unique. In the design of schools ventilation is usually achieved through the windows and there must therefore be a compromise between the conditions respectively most ideal for lighting and ventilation. Mr. Widdows has avoided this difficulty by arranging for ventilation through doors, which are arranged to run the whole length of both sides of the classroom. The doors can be opened as a whole, and the top half of the door can also be dropped or only lowered a few inches. This utilisation of the upper door-area is useful on cold days as it provides for access of fresh air into the upper part of the room without causing a cold draught round the feet of the children. Moreover the fact of having doors along both sides of the room makes it possible to provide ventilation from either side, according to the direction of the wind.

It has generally been assumed in school-lighting that access of light must be provided mainly by windows in the vertical walls. As a rule the construction of the building makes this obligatory but it is evident that when schools can be specially designed with a single story an inclined sky-light may be more efficient. Mr. Widdows has therefore made use of a continuous sky-light inclined at 60 degrees with the horizontal on the north side of the rooms. This gives abundant and very even illumination, the "north light" being recognised as the best form of daylight illumination for studios and other cases where a steady illumination is wanted. Some dormers on the south side have also been provided as it was thought desirable to allow access of sunlight into the rooms from time to time. These windows can be screened with curtains in cases where the cross-shadows cast by them are apt to be inconvenient. Even with the curtains drawn the least-lighted part of the room receives as much as 5 per cent. of the outside unrestricted illumination—a very high value when it is remembered that schoolrooms where the minimum illumination is not less than one per cent. of the outdoor illumination are usually considered to be well-lighted.

The heating of the school is also arranged on a novel plan. A steam boiler working at 3 lb. pressure is provided. The floors are made of concrete with grid-iron trenches into which the steam pipes are taken. Over the trenches are laid stone slabs and the heat rises from the floor and is thus very evenely communicated throughout the room. The system is said to be exceptionally efficient. The only other heating in the rooms is afforded by a steam pipe running round the rooms immediately under the level of the skylights. This serves to prevent a down draught. With this exception the piping is entirely out of sight but can easily be reached at any time by merely lifting the stone slabs ;

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* May, 1916.

the absence of unsightly masses of pipes round the room is a distinct advantage.

In order to illustrate the uniformity of the distribution of heat it is mentioned that the temperatures one foot and six feet above the floor were respectively 59° and 57°. The floor-temperature need not exceed 75°, and this should not be trying to people with normal feet.

Mr. Widdows was no doubt fortunate in the conditions under which this design was carried out, and it may naturally be difficult to secure equally satisfactory arrangements in large many-storied town schools in congested areas. The experiment is, however, well worth notice by those concerned with country school design. Other schools of the same type were to have been erected in Derbyshire, but the work has been interrupted by the war. Let us hope, with Mr. Widdows, that "all the efforts which have been put forth to improve the lot of the school child will not be brought to nought, and that the education and housing of the children will not be the first thing to suffer when the much-longed-for peace comes."

TWO NOVEL SAFETY-DEVICES.

A RECENT issue of *Popular Mechanics* describes two novel safety-devices being employed in America.

The first of these is a periscope of large size which is mounted in the signal cabin near a somewhat complicated piece of track on the Elevated Railway of Chicago. This enables the operator to observe the motions of adjacent trains when they would otherwise be out of the direct range of vision.

The second device involves the use of a luminous hand, which is compased of translucent material and illuminated by a small glow lamp placed within it. This is used by motorists at night, being thrust out to right or left to indicate a turn, just as the driver ordinarily uses his hand in the daytime.

TESTS OF STREET ILLUMINATION.

IN a recent paper before the Illuminating Engineering Society in the United States, Mr. P. S. Millar draws a distinction between tests of the effectiveness of the lighting, and tests to determine compliance with a legal contract. The latter should be based mainly on the specification of certain lamps, arranged in a particular manner and operated under prescribed conditions. If a test of candle-power is enforced this should relate to the total flux of light from the lamps used. This is most conveniently tested with an Ulbricht Globe in the laboratory, but Mr. Millar also shows an illustration of such a test being carried out in the street. The Globe and accessories are mounted on a motor-trolley. This is brought immediately under the lamp to be examined and the lamp is lowered through the aperture at the top of the globe.

A description is also given of a very interesting series of experiments carried out in a length of street in Philadelphia. Besides tests of the total light-flux of each lamp, the horizontal illumination at street level, the vertical illumination 4 ft. above the street, and the surface-brightness of the street were determined. In order to determine the "revealing power" of the illumination small discs and cylinders, painted the same tint as the street-surface, were distributed along the roadway and foot-passengers and people riding were asked to pick them out. Results of this test suggest that absolutely even illumination along the street is not essential, since variations in brightness are often useful in enabling the "silhouettes" of obstructions to be recognised. On the other hand great extremes of illumination, such as are met with on country roads, are naturally unsatisfactory.

COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

REPORT OF THE ADVISORY COUNCIL FOR THE YEAR 1915–1916.

The Advisory Council, which was constituted by Order of Council dated July 28th, 1915, has now issued a Report for the past year, summarising the most important steps already taken for promoting scientific and industrial research.

In referring to previous Governmental action in this direction a tribute is paid to the work of the National Physical Laboratory. "The Laboratory," it is pointed out, "has done and is doing most valuable work for our industries and for the Government, and it might have done much more had it been endowed with anything like the annual subvention of nearly £100,000 which the American Bureau of Standards receives for development and maintenance from the United States Government." But experience has shown that no single institution, however great or distinguished, can expect to do more than a part of all that our vast industries require.

The foundation in 1907, under a Royal Charter, of the Imperial College of Science and Technology was also a most important step. Within the last few years science and engineering have also received more encouragement at Oxford and Cambridge, and there have been important developments at many of the northern and provincial universities.

The flotation of the great company, with a possible ordinary share capital of £3,000,000 (against which the Treasury undertook to make advances up to a limit of £1,500,000 secured by debentures) for the manufacture of dyestuffs and similar chemical materials required by the textiles industries of the country, is perhaps one of the most important ventures since the outbreak of war.

AIMS AND OBJECTS.

In explaining the steps leading to the action so far taken for the promotion of scientific and industrial research, the Report emphasises the urgency of the problem and its future significance.

"The brains, even the very processes, that to-day are necessary for the output of munitions were yesterday needed, and will be needed again to-morrow, for the arts of peace. . . ." This is the central fact which justified the establishment of the new machinery in the midst of a struggle that is absorbing the whole energies of the nation in a way no previous war has done. It has been questioned whether it would not have been wiser to avoid the inevitable difficulties resulting from the war by postponing action until peace was restored. Mr. Henderson foresaw this criticism when he remarked that "we cannot hope to improvise an effective system at the moment when hostilities cease, and unless during the present period we are able to make a substantial advance we shall certainly be unable to do what is necessary in the equally difficult period of reconstruction which will follow the war."

"PURE" AND "APPLIED" SCIENCE.

The Council, however, decided to give science in its applications to industry precedence over "pure science." While they are under no misapprehension as to the relations between pure and applied science and recognise that what is commonly called "applied science" is merely the application of pure science to particular classes of problems, they point out that in this matter they have to deal with the point of view of the practical business world. "The average manufacturer is impressed with the importance of quick returns; he cannot afford to wait. The managing director of one manufacturing firm recently told us that he had no interest in research which did not produce results within a year. If science can help him to overcome the difficulties that cross his path from day to day he welcomes her. He wants a handy servant, not a partner with ideas of his own."

No doubt there are firms which take a more enlightened view, but the scepticism of the average business man is natural. The difficulties that present themselves to manufacturers and merchants seldom afford an indication of the true nature of the problems to be solved. They are generally secondary in their nature, and a direct attack on them is likely to be as empirical as the symptomatic treatment of disease. Thus such quick-result inquiries as the manufacturer is induced to make are very likely to be fruitless and to reduce his enthusiasm for science still further.

Another consideration that inclined the Council towards the encouragement of researches having a directly practical application was that the universities, the natural homes of research in pure science, have been so depleted of students and teachers by the war that they are barely able to continue their routine work and can command neither the leisure nor the detachment of spirit that are essential conditions for original research.

STANDING COMMITTEES.

They have, therefore, also tried to work through the agency of Standing Committees dealing with such subjects as metallurgy, engineering, mining, &c., on which the great professional institutions concerned, working in conjunction with the Home Office and the Board of Trade, are adequately represented. Other Standing Committees in contemplation include those on Fuel, Rubber, and the Chemistry of Cotton and Paper, and a Standing Committee for Textiles with special sections for Cotton, Wool, and Silk.

In addition, advantage has been taken of the research facilities of many educational institutions and universities, and of the leading Trade Associations and Professional Institutions and Societies throughout the country, including the Institute of Chemistry, the Society of Chemical Industry, the Society of Public Analysts, the Society of Dyers and Colourists, the Royal Institute of British Architects, the Faraday Society, the British Electrical and Allied Manufacturers' Association, the Staffordshire Pottery Association, the Silk Association, the Federation of Master Printers, &c.

A compilation of a Register of the Researches actually being conducted by Universities and Institutions throughout the country has been undertaken, and a careful survey is also to be made of the facilities for research throughout the country. It is hoped that the Register will enable workers on specific subjects to be found when new proposals for experiments are brought forward. Speaking generally, the great need is for Organisation and Co-operation. It is gratifying to note the statement of the Committee that:—

"In the numerous conferences we have had with representatives of different industries, we have been impressed by the spirit of co-operation which is growing up and the willingness to accept our suggestions for the initiation of research for the benefit of the trade as a whole."

EXAMPLES OF EMERGENCY RESEARCH.

The emergencies arising on the outbreak of war have in themselves induced many manufacturers to act. Thus the great steel manufacturers were in grave danger from the possible exhaustion of the supply of chemical glass necessary for the testing of their materials. Consulting chemists were in the same difficulty. The work of the Institute of Chemistry has done much to remedy this deficiency. Similarly, pottery manufacturers were in lack of the Segar cones necessary as a guide to the firing of their china and earthenware. Dr. Meldola, the Principal of the Stoke Pottery School, stepped into the breach, and was soon able to manufacture sufficient cones for the whole pottery trade. This and other facts led eventually to the erection of special research laboratories and workshops in connection with the Stoke School of Pottery, for which a special grant was given by the Board of Education, and where experiments on the manufacture of hard porcelain with British materials are being conducted.

CO-OPERATION OF TRADE ASSOCIATIONS.

There has also been a significant movement towards forming powerful Trade Associations, resembling those prevailing abroad, and in several cases these Associations are already taking steps to foster research in their respective industries. It has been pointed out that a manufacturer who requires information is under a drawback in being obliged to consult an individual expert and to bear personally the whole burden of the fees involved. There is need for the establishment of a great central institute, where joint researches can be conducted for the benefit of all the members of an industry. Equally pressing is the problem of devising facilities for finance similar to those provided abroad by the industrial banks. The Board of Trade has appointed a Committee, under the chairmanship of Lord Faringdon, "to consider the best means of meeting the needs of British firms after the war as regards national financial facilities for trade, particularly with reference to the financing of large overseas contracts, and to prepare a detailed scheme for the purpose."

"KEY-INDUSTRIES" AND STATE ASSISTANCE.

The fear has often been expressed that there is no security that, after new ventures have been undertaken, manufacturers will not be left at the mercy of the highly-organised competition of foreign countries after the war. There appears to be no single specific remedy. Organisation can only be met by counter-organisation, and the solution of the difficulty must lie in co-operation of an industry as a whole, in place of the independent efforts of manufacturers acting as individual units. On the other hand, in the case of certain "key-industries," on which many others are dependent, provision may be taken for some State assistance. Apart from their industrial importance, these highly scientific trades deserve recognition in view of their educational and intellectual value, and their influence in raising the status of the industrial life of the nation.

In any case a healthy condition of such industries can only be secured if, for some time to come, a good deal of attention and money are expended upon convincing the manufacturing world that scientific research is a paying proposition. In this connection an interesting analysis is made of the conditions in the United States, and the respective parts played by Universities and manufacturing concerns in promoting research. As examples the highly developed arrangements of the Eastman Kodak Co. and the National Electrical Lamp Association are quoted. It is interesting to note the contribution of the Prussian Government to the optical work of the firm of Schott of Jena is, apparently, the only instance of *direct* assistance derived from the German Government. On the other hand, the German States spend lavishly on their education, particularly upon Universities, Technical High Schools, and Research Laboratories, from which the industries as a whole benefit.

RESPECTIVE OPERATIONS OF UNIVERSITIES AND RESEARCH INSTITUTES.

The view has been expressed that Universities are not well adapted for long-sustained researches requiring considerable industrial equipment, and the allocation of their activities to "pure science" of benefit to humanity as a whole, and "applied science," in connection with specific industries, requires careful study. There is doubtless a field for special research institutes, such as the Stoke Pottery School and the Research Institute for Glass at the University of Sheffield, and the plan adopted in America of granting fellowships for researches on specific subjects, with the support of the industry concerned therein, also deserves mention.

CONCLUSION.

After referring to the measures for developing industrial research now being taken in various parts of the Empire, notably in Australia, the Report offers several tentative conclusions. Among the conditions essential to the realisation of the aims they have in view are: (1) A largely increased supply of competent researchers; (2) a hearty spirit of co-operation among all concerned, men of science, men of business, working men, professional and scientific societies, Universities and Technical Colleges, Local Authorities, and Government Departments.

Progress in the immediate future must necessarily be slow. It appears certain that the number of trained research workers who will be available at the end of the war will not suffice for the prospective demand.

No less important than the co-operation of men of science and manufacturers is the co-operation of the workers themselves. It is significant, if singular, that the making of weapons of destruction for the war has afforded unique opportunities of humanising industry. The problems involved in munition work have given a great impetus to the study of the conditions of labour and to the Welfare movement. More cordial relations between employer and employee will do much to smooth the path of industrial reorganisation.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

Tenth Annual Convention.

We recently published a summary of the papers to be read at the Tenth Annual Convention of the Illuminating Engineering Society in the United States, to take place in Philadelphia during September 18th—20th.* We are now informed that the Presidential Address will this year be delivered by Dr. Chas. P. Steinmetz, and that reports of the Committees on Progress and Nomenclature and Standards will be presented.

The special course of twenty lectures on Illuminating Engineering is to be given immediately after the Congress at the University of Pennsylvania, on September 21st—28th. We notice that a reprint of all the lectures will be issued, the cost of which is included in the tuition fee of 25 dollars.

UNEVEN LIGHTING AND ARCHITECTURAL EFFECT.

Mr. Morgan Brooks, in a paper before the Illuminating Engineering Society (U.S.A.), remarks that non-uniform illumination often produces a special architectural effect. For example, if the stage in a concert room receives a strong illumination, the front of the auditorium somewhat less light, and the back portion less still, the effect is to diminish the apparent length of the hall—often a useful result in long and narrow rooms, especially if the back rows of seats are empty.

GAS RESEARCH FELLOWSHIPS AT ILLINOIS (U.S.A.).

According to the *Gas Age*, the Illinois Gas Association has arranged with the University of Illinois for the establishment of a research fellowship on gas engineering and is providing 500 dollars for a period of four years for this purpose.

The officers of the various companies represented in this Association will each nominate one or more members of their staff for the fellowship. The list of names thus prepared will be submitted to the Director of the Engineering Experiment Station of the University who will select the successful candidate.

The results of any researches carried out will be the property of the University for dissemination to the public through such channels as it may select.

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* *Illum. Eng.*, July 1916, p. 222.

ILLUMINATION IN THE NAVY.*

By Lieut. C. S. McDowell, U.S.N.

Illumination of Spaces on Shipboard.

This term includes the lighting of the living spaces for officers and crew, machinery spaces, firerooms, turrets and gun compartments, shell rooms, powder magazines, sick bays, coal bunkers, upper deck spaces, gangways, &c.

The lighting on board ship meets special requirements. In some cases lights serve several distinct uses. Fittings must be designed to meet special conditions imposed by low head room, liability to damage through shock from gunfire, and the necessity to maintain the integrity of water-tight compartments. In 1912 the Navy Department started a special investigation into these matters, eventually drawing up a table of values for the intensity required for various purposes, as summarised in Table I. It is interesting to notice that as a result of the low ceilings and white wall surfaces semi-indirect and indirect devices are

ILLUMINATION REQUIRED FOR VARIOUS PURPOSES ON BOARD BATTLESHIPS.

Foot-candle Intensities.

Ammunition passages	2.0
Armory, plus metal reflectors at bench	2.0
Battle dressing station	2.0
Battle dressing stores	2.0
Bakery	2.0
Bath room	2.0
Barber shop	2.5
Boiler rooms, plus 250-watt units	1.5
Butcher shop	1.5
Band room	1.0
Blower room (special)	—
Blower space	1.0
Cabins	3.0
Carpenter shop	3.0
Chart house	5.0
Chief P.O. quarters (berthing)	1.5
Chief P.O. quarters (messing)	2.0
Crew's space	1.5
Conning Tower (officers')	1.5
Crew's wash room	2.0
Crew's water closets	2.0
Conning tower (special)	—
Chain locker	1.5
Coal bunkers	0.7
Coaling ship (special)	—
Dispensary	3.0
Desk	4.0
Distribution room	2.0
Dynamo room, plus 250-watt units	1.5
Decks, outside (special)	—
Engine room, plus 250-watt units (treated special)	1.5
Evaporator room	1.5
Firemen's wash room	2.0
Foundry	3.0
Fire room (treated special)	—
Fuel oil relay tank room	2.0
General condiment and issuing room	2.0
General mess pantry	2.0
Galleys	2.0
Handling room	2.5
Interior com. room	2.0
Ice machine room	2.0
Isolation room	2.0
Issuing and store room	2.0
Laundry	1.5
Lamp room	1.5
Machine shop (general)	1.0
Magazine	1.5
Mess rooms (officers')	2.5
Mess attendants' wash room	2.0
Offices	4.0
Operating table	15.0 to 25.0
Paint room	1.5
Paint mixing room	1.5
Pantries	2.0
Printing office	4.0
Pump room	1.5
Post office	4.0
Prison (special)	—
Reception room	3.0
Surgeon's examining room	2.0
State rooms	3.0
Sub	4.0
Sub central	4.0
Shell room	2.0
Store rooms (fixed stores)	0.7
Store room (stock for issue)	1.0
Sick bay	2.0
Storage battery chg. sta.	2.0
Ship's store	2.0
Torpedo room	2.0
Turrets (special)	—
Water closets	1.0
Wireless room	3.5
Workshop (additional special illumination to be provided at machines)	1.5
Windlass space	1.5

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* Abstract of Paper read at a meeting of the Illuminating Engineering Society, U.S.A, (*Trans. Am. Ill. Eng. Soc., U.S.A.*, July, 1916.)

largely used. Carbon filament lamps are employed for portable lamps, with a view to diminishing danger of breakage; otherwise tungsten lamps of 25, 40, 60 and 250 watts are chiefly used. 250-watt units are installed in the engine rooms.

The standard voltage until the last two years was 120 volts; on the newer battleships, however, 240-volt generators and a three-wire system are installed, the lighting circuits from the distributing boards being thus still 120 volts.

On board battleships there are two regular lighting circuits known as "battle" and "lighting" respectively. The battle circuit includes all circuits below the protective deck, circuits to guns, searchlights, signalling apparatus, running lights and in general all the lights which would be absolutely necessary in action. Lighting circuits include those which may be dispensed with in action. In addition to the above there is installed an auxiliary or emergency lighting circuit fed with 20 volts from storage batteries.

SEARCHLIGHTS.

The chief essential in the modern searchlight is to obtain a source of minimum area and maximum brightness. For many years the arcs used have remained substantially the same, but quite recently great improvements have been made by using a higher current density in the positive electrode, means being provided to carry off the heat; and at the same time using a smaller negative carbon, so as to obstruct less light. In the latest searchlights the diameter of the positive carbon has been decreased to half its former value, and at the same time the current has been increased so that, with a crater of $\frac{5}{8}$ in. diameter, a maximum luminous intensity of 90,000 candles throughout an angle of approximately 70 degrees is obtained. Moreover, the size of the crater is so diminished that the area of the beam is reduced to one fourth of that previously obtained; as the candlepower has also been increased from 50,000 to 90,000 the actual illumination on the target is more than six times the amount formerly attained.

The composition of the positive carbon is very important, a core of white flaming material being used. The negative carbon is set at an angle to the positive with a view to confining the luminous flame within the crater. This effect seems to require a certain minimum current of approximately 90 amperes. The standard diameter for mirrors is 36 in. The negative is only $\frac{7}{16}$ in. diameter, being also about half that used with the older type of arc.

In the discussion, Mr. Sperry and Mr. W. Bassett Jones referred to the Beck searchlight. Although the work in America has proceeded on somewhat different lines equally good results have been obtained. It was mentioned that although the carbons were approximately the same size as those used in the Beck searchlight the crater-area is about 30 per cent. less, thus giving a still smaller angle of dispersion.

INCANDESCENT SEARCHLIGHT UNITS.

Tests have also been carried out with gas-filled incandescent lamps having concentrated filaments. This type will probably be satisfactory for navigation purposes where it is not necessary to illuminate objects at great distances.

As such filaments, being approximately "point lights," give a more or less uniform distribution of light, short focus mirrors embracing as large as possible a proportion of the luminous flux, are desirable.

In the discussion L. C. Porter remarks that the various types of "flood-light" projectors now available should be very suitable for navy work, around docks and piers, and especially for loading and coaling. Focus-type incandescent units for searchlights ranging from 1 to 5,000 candlepower are now made. There is, for example, one unit comprising a single lamp fed from a dry battery which will throw a beam with an effective range of 200—300 feet.

EFFECT OF COLOUR OF THE BEAM.

The question of the colour of the projected light is also interesting. From one standpoint the accentuation of the green and blue component in the arc light is advantageous, namely, that on account of the low illumination of distant objects, the sensitiveness of the eye to this region of the spectrum is exceptionally high; moreover, objects illuminated are frequently of a bluish-grey colour. On the other hand the longer wavelengths are less absorbed in a mist or fog. In some experiments conducted with an artificial fog it was found that, when using silvered glass mirrors the illumination of an object 50 ft. distant from the light through the fog was but 21 per cent. of the illumination under normal conditions; but by using a gold plated mirror the illumination under the same conditions was 60 per cent. of that obtained under normal conditions.

In addition, owing to the chromatic aberration of the eye the visual acuity with a gold-backed mirror, is, for the same illumination, greater than with a silver-backed mirror, and distant objects "stand out" in greater detail. The gold-backed mirror has been extensively used by some countries, but it is doubtful whether its use is advantageous with the latest type of arc which contains a strong blue and violet element. In the discussion Mr. L. C. Porter remarked that tests he had made with an amber front glass showed that in these circumstances signals near to the searchlight could be somewhat more readily picked up, owing to the diminution in glare. But he did not find that objects could be picked up at a greater distance with an amber beam than with a clear beam of equal intensity.

Evidently there is still considerable difference of opinion on this subject.

SIGNALLING BY MEANS OF LIGHT.

Distant signalling is made mainly by means of the following systems:—Ardois; night semaphore; blinker light; searchlight.

The ardois consists of four lamps mounted in a vertical line, as high as possible in the rigging. Each lamp contains a red and a white lamp, and the lights are controlled by a keyboard similar to that used on a typewriter. The Morse code is used, red lamps indicating a dot and white ones a dash. The system is very easy to use as the keys are all lettered and numbered, but it can only be used for relatively short distances.

In the semaphore system use is made of a machine with two swinging arms, which can be manipulated to represent the letters of the alphabet by their relative positions. These arms can be equipped with tungsten lamps and reflectors so as to be readily visible by night.

The blinker system employs a pulsating light source, such as an incandescent lamp with tapping key, controlled from a telegraph board, rapid signalling being transmitted by the intervals of lighting up and extinction of this lamp. This is only available for night work.

The use of the searchlight is well adapted for signalling over long distances, even as great a distance as 50 miles having been covered. It has, however, given place to some extent to wireless telegraphy. The light from searchlights can be alternately made visible and extinguished by means of electrically operated Venetian shutters. Other methods of producing the fluctuation in light without striking the arc have been devised. For example, if the arc is struck with a relatively high frequency and high voltage it can be maintained at a low voltage. By shunting the arc with a resistance the current in the main line may be maintained constant and the current across the arc reduced to about one-tenth of its normal value. The variation in light thus produced gives the same effect as if the arc were actually shut on and off.

Searchlight-signals can be conveyed in the daytime. Even with small searchlights as much as eight miles have been covered by day, the light being directed straight at the observer on the same principle as a heliograph. For long distance night work the beam is usually directed on some dark cloud in the direction of the receiving ship.

There are also many other special problems on board ship, such as the illumination of compass cards. This must be so arranged that the markings of the compass are quite distinct but no glare is present. Another example of special uses of light is the illumination of the cross wires of telescopic gun sights.

STREET LIGHTING PROBLEMS IN WAR TIME.

A recent issue of *Municipal Engineering and The Sanitary Record* comments on the difficulties which Corporations and District Councils are experiencing in satisfying simultaneously the requirements of various authorities in adjusting the public lighting in war time.

As the question is one of considerable interest at the present time, we are reproducing some of the comments of our contemporary in the article referred to. The various points raised deserve consideration, and it would be desirable for any apparent misunderstanding to be cleared up.

It is stated that:—

"By a series of somewhat erratic and unpractical requirements, the lighting authorities have been induced in many cases to continue the consumption of gas and electricity in the public lamps, the illumination being wasted by restricting it to the interior of such lamps by coating over the glass, so that no rays shall be reflected on the surface of the street. The demands of the Government authorities are, of course, based on the Defence of the Realm Regulations, 1914, and an Order of the Secretary of State made thereunder, but it is probable that some confusion has arisen through the different powers which affect Metropolitan Borough Councils, as compared with Local Authorities outside the Metropolis. For whilst such Borough Councils are compelled under Sec. 130 of the Metropolis Management Act, 1855, to cause the streets within their districts to be well and sufficiently lighted, there is no such duty cast upon Councils outside the Metropolis. In the district immediately outside the Metropolitan Boroughs there is a considerable area containing numerous Boroughs and District Councils, which are under the jurisdiction of the Metropolitan Police, such area being legally defined as the Metropolitan Police Area. Many of such Councils, we have observed, have recognised the futility of the expenditure of wasting an illuminant for confinement within obscured glass, and have approached the police authorities for their assent to discontinue the practice. Such assent is invariably postponed, and many of the Councils have submissively continued the unjustified expenditure. Some Authorities, on the other hand, discontinued public lighting except at important street intersections six months ago, and have saved the ratepayers very considerable sums of money. If the requirement of the Government department was essential for the safety of the inhabitants of any district, no demur could be raised to it. In the Metropolis, where the street traffic is, of course, heavy, and where the authorities are bound to execute public lighting, it is requisite for the safety of pedestrians. But in extra-Metropolitan districts public lighting is really inimical to public safety, for it attracts prowling Zeppelins. When we come to examine the legal aspect of the question, it is found, as stated by our contemporary, the *Justice of the Peace*, in its issue of September 9th (page 171), that the claim of the police, empowering their chief officer to require a District Council to light such of the street lamps as he directs, is unfounded. They point out that Regulation 11 of the Defence of the Realm (Consolidation) Regulations, 1914, empowers the Secretary of State by order to direct that lights shall be extinguished or obscured. But the regulation does not empower him in any other respect to require lights to be provided or public lamps to be kept in use. The Order of July 22nd, 1916, made under the regulation, and under which the police claim to act, must be read with the regulation, and could not extend the power conferred by the regulation, and this legal view of the case will doubtless be helpful to many Local Authorities throughout the kingdom."

LIGHTING REGULATIONS IN GERMANY.

In this country we have now had time to become accustomed to the lighting restrictions. The attempts that have been made to define the permissible brightness of lights in this country have been the subject of some comment, and although the problem is admittedly not an easy one, lighting experts cannot help being struck by the somewhat vague and indefinite nature of many of the terms used.

It is therefore interesting to notice that similar precautions are now being taken in the naval ports of Germany, and to compare the wording of their regulations with our own. According to a recent issue of the *Evening Standard*, the following announcement ordering more stringent precautions has appeared in the *Wilhelmshaven Zeitung*:—

> "No more lights are to be shown in streets, yards, gardens, private or public buildings. Curtains and blinds which have hitherto been considered a satisfactory precaution are now regarded as insufficient. Illuminated signs are prohibited, and all the special light-permits are withdrawn. Shop-windows are to show no more than just sufficient light to enable customers to distinguish the goods.
>
> "Rehearsals of the arrangements for the safety of the public will be held nightly until further notice."

Certainly some of these requirements —especially that dealing with the highly problematical illumination required to "enable customers to distinguish the goods"—are not particularly explicit.

FESTIVAL LIGHTING IN THE UNITED STATES.

In the *Journal of Electricity, Power and Gas* an account is given of some interesting spectacular lighting—a form of lighting with which we in this country have necessarily become unfamiliar since the outbreak of war.

On the occasion of the Portland Rose Festival at Portland, Oregon, special electric lighting devices played a prominent part. These included various symbolic signs associated with the history of the town, such as 30 ft. white columns, bearing in a niche a figure of Sacajawea pointing the way to the festival centre, and decorated with paintings "presenting the scenic wonders of Oregon." These columns were illuminated from head to foot with concealed "flood-lighting." The chief feature was the erection of a "rose-fountain," where, by a combination of trailing green shoots, flowing water and winking rose-coloured electric lights, a fountain of roses bubbling over in a foaming spray was simulated. It is stated that the individual efforts of householders were kept in harmony with the civic decorations so as to aim at a co-operative display.

Whatever views one may hold as to the artistic value of such spectacular lighting, it cannot be denied that in these American cities there is often a touch of imagination about the decorations, which has not always been a feature of attempts at festive lighting over here.

What, one wonders, will be the nature of the illuminations when peace is at last declared? Will there be an attempt at a co-operative effort worthy of the occasion? Or will we once more fall back on the old studded lights, crowns and similar time-honoured devices which have done service in times gone by?

THE CONTRACTOR AND THE ARCHITECT.

The architect and the general contractor have in the past usually ignored the electrical contractor until the time arrived for the latter to bid on the work, and then the amount of his bid was the only feature of interest about him. This has been partly due to the fact that the average electrical contractor was only concerned in the mechanical end of the installation work and was not prepared to offer any advice or suggestions as to plans and specifications. To-day, however, many contractors are giving close study and attention to the requirements of their work, and architects and engineers might receive valuable aid in planning the electrical equipment by taking the electrical contractor into their confidence.—*Electrical Review and Western Electrician*, August 5th, 1916.

A NEW DEVELOPMENT IN HIGH PRESSURE GAS LIGHTING.

In the course of the Presidential Address delivered by Mr. Alexander Masterton, of Edinburgh, before the North British Association of Gas Managers on September 2nd, some particulars were given of a new development in high pressure gas lighting, of special utility in factories where there is much dust or fluff in the air.

This new form of lighting is installed in the works of the North British Rubber Company, which for many years was lighted on the low pressure system. It was recently decided to try to improve matters by applying high pressure lighting, with a view to possible application to extensions of premises as well as in the old works. Accordingly a high pressure plant with compressors in duplicate driven by electric motors was fitted up, and 80 candlepower lamps, consuming from $1\frac{1}{2}$—$1\frac{3}{4}$ cub. ft. per hour, introduced. It was desired to diminish the amount of gas used, as compared with the low pressure lighting, by 40 per cent.—a result which has now been successfully accomplished.

The lamps originally installed were of the ordinary Keith type, with an enamelled reflector and glass globe, having a central opening at the bottom and kept in position by wire clips. The effect was good. However, in a rubber factory with so much inflammable material about, insurance restrictions are severe and naked lights are banned. It was therefore desirable to adopt a method of lighting up, which, while not exposing a naked light, would also, through usage, not damage the mantles and glass. In view of the small consumption of the burners it was evident that a by-pass going continuously would consume in the course of the year practically as much as the burner. An electric torch was therefore devised somewhat on the lines of the "Telephos," consisting of a battery with a long igniter and push-button. This worked fairly well, but the cost was rather high and the igniter had to be held pretty close to the mantle to ensure lighting. In this way many mantles were broken.

These troubles, combined with the dusty atmosphere which prevails in many portions of a rubber factory, led the James Keith and Blackman Co., who had experienced the same difficulty in other places, to bring out what is termed the "Duct" system. In this system a special box conveying fresh air (free from the inside dust) from outside is led through the building, and the high pressure gas is coupled up at various points in its length, each of these connections supplying, by means of one injector, a number of high pressure burners.

One advantage of this arrangement is that the injector, being of large capacity, is not liable to get choked. The correct quantity of fresh air is drawn in from the duct, the mixture of gas and air being forced along a pipe $\frac{3}{4}$ in. or 1 in. in diameter, to which the burners are attached at suitable positions. The burners consist of a flexible down-tube to compensate for vibration, with a heating chamber at the foot, to which the nozzle is fixed on the lower side and on which, in turn, the mantle is screwed. Small square opal reflectors in four pieces are fitted immediately above this to throw the light down on the tables or machines. No globe of any kind is required, but a small round wire gauze is hung about two inches below the mantle so as to intercept any ash or mantle-rings, should they fall.

The chief advantages of the system are that, owing to the capacity of injectors and absence of nipples or air-adjustment, chokage through dust is obviated; in the case of dust-laden atmospheres, fresh air can be led in from outside the building while, in ordinary factories, the duct can be connected to the air supply inside the room. No globes are required, which should lead to a saving in maintenance. The consumption can be brought down to one cubic foot per hour or even less; this should enable relatively small high pressure lights of low candle-power to be easily obtained.

It was also mentioned that Mr. Keith had been experimenting for some time in the direction of obtaining a thoroughly reliable lighter which would meet the requirements of insurance companies, and that he had now evolved a satisfactory arrangement.

A SUPER-EFFICIENCY CARBON FILAMENT LAMP.

Under the above title the *Electrical World* describes a new patent of the Siemens and Halske Co., of Berlin. This describes a proposed form of carbon filament lamp credited with a specific consumption even less than that of the so-called " half-watt " lamp. The inventors' names are given as H. Kreusler, H. Gerdien, and M. v. Pirani.

The lamp appears to be a return to the oft-exploited idea of enclosing carbon filaments in an atmosphere of mercury vapour. Within the outer bulb, which has a long neck somewhat similar to that used in half-watt bulbs, there is a cylindrical chamber filled with nitrogen, argon, or other insert gas. The filament is in the form of a stout spiral, and is situated close to the bottom of the bulb. Below it is a small amount of mercury. As soon as the filament is heated by the passage of the current the tube becomes filled with mercury vapour and the inert gas is partly driven out through the top of the inner tube into the surrounding envelope.

The outer tube glass surface remains relatively cool and is thus able to withstand the comparatively high internal pressure, which is above atmospheric.

A NEW NOTE IN STREET LIGHTING.

According to the *Electrical World* a new note is being struck in the street lighting at San Francisco, where some of the experience gained in the exhibition last year is evidently being applied. An attempt is being made to aim at something more decorative than the average street lighting.

The three main characteristics of the new lighting are as follows :—

(1) The colour-tone is a golden glow instead of the somewhat hard white usual in American cities, the colour being obtained by special tinted globes.

(2) Free use is made of arcs in groups instead of single units, those groups being placed at an exceptional height so as to diminish glare and improve the distribution of illumination. The overall length of the new decorative standards is given as 32 ft.

(3) Street Railway Poles have been mainly utilised, thus reducing the number of standards in the streets.

In some parts of the city standards carrying a combination of arcs and incandescent gas-filled lamps are utilised, the colour of the globes used for the latter being selected so as to match the light of the arcs.

COGS IN THE INDUSTRIAL WHEEL: WELFARE WORK AND WHAT IT MEANS.

By Mrs. M. A. Cloudesley Brereton, M.R.San.I., F.I.H., &c.

One of the chief causes of industrial unrest, as indeed of most human ills, has been the tendency of the mass of mankind to think in terms of " rights " rather than of " responsibilities." The individual is apt to lose sight of his own duties towards others in the emphasis laid upon his duties towards himself and those of others towards him. In industrialism this tendency is constantly making itself felt, and not least in that modern development of the doctrine of responsibility which is known as " welfare or social work."

A Notable Book.

Now welfare work, to give it its generally recognised title, is no new thing, no mere war-time expedient; it was known in the land before the passing of the Factory Acts. Defined as " voluntary efforts on the part of employers to improve, within the existing industrial system, the conditions of employment in their own factories," we can note its workings in the early years of the Nineteenth Century, and it would be idle to deny, in the face of evidence brought together in the volume entitled *Welfare Work*,* that the manufacturers themselves played a considerable part in the movement for factory legislation. This book is the work of Miss Dorothea Proud, a graduate of the University of Adelaide, who brought to her task the fruit of many years of patient inquiry and research into the conditions of welfare work as carried on in the factories of the Commonwealth and of Great Britain, and is now serving in the Welfare Department of the Ministry of Munitions, under the direction of Mr. B. S. Rowntree. Miss Proud's very valuable and illuminating book is prefaced by a foreword from the pen of Mr. Lloyd George, who speaks with the greatest enthusiasm of the work undertaken by this Department since its inception, and prophesies that welfare work as practised in the munition factories of to-day will in happier times of peace become one of the most important cogs in the industrial wheel. " It is a strange irony," he says, " but no small compensation, that the making of weapons of destruction should afford the occasion to humanise industry. Yet such is the case. Old prejudices have vanished, new ideas are abroad; employers and workers, the public and the State, are all favourable to new methods. The opportunity must not be allowed to slip. It may well be that, when the tumult of war is a distant echo, and the making of munitions a nightmare of the past, the effort now being made to soften asperities, to secure the welfare of the workers, and to build a bridge of sympathy and understanding between employer and employed, will have left behind results of permanent and enduring value, to the workers, to the nation, and to mankind at large."

Philanthropy or Profit?

We read in Miss Proud's book of employers of an earlier day who endeavoured to keep secret their enlightened treatment of their workpeople in order to protect other employers less fortunately placed; we read also of others who demanded legislation as a means of bringing tyrannical or callous employers into line with their own greater humanity. Here we see the ever-present conflict between rights and responsibilities, as we see it in the suspicious attitude towards " welfare work " that persists even to-day among not a few workers. They so little understand the meaning of responsibility that any concession on the part of their employer seems to them a mask for some act of aggression—the preliminary, say, to a reduction of wages or an increase of hours. To the open-minded, however, welfare work in its truest sense implies a condition of strict justice: the employer realises what he owes to his hands in the way of decent treatment, but expects in return his fair measure of honest work from them and penalises those who come short in this respect, the workman feels that just as he has a right to healthy and decent conditions so too his master has a right to the best work that these conditions make possible.

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* A notice of this book appears on p. 290.—Ed.

Thus all fear of the much-hated "philanthropy" or "charity" is eliminated from the relationship of employer and employed. It is of course undoubted that pity forms a strong element in the modern tendency of employers to reproduce as far as is possible the personal intercourse and almost paternal care which used to be the basis of the contact between master and man; but there is another potent force to be considered, the hope of profit. This motive, in Miss Proud's experience, is the only one tolerated in America, but in this country neither pure business nor pure philanthropy is the chief spur to action. No doubt the opinion is gradually gaining ground that, as W. T. Layton puts it in *Capital and Labour*, "'Welfare work' is not only a means of satisfying the humanitarian instincts of employers, but is also a commercially successful device for improving the efficiency of business. . . . The evidence on the whole goes to prove that there is a distinct monetary gain both to employers and employed from wholesome conditions in the factory and from attention to the physical fitness of the operatives": testimony is, for instance, repeatedly given as to the fact that shorter hours generally mean increased output. The keynote, however, of the whole welfare movement is the recognition of personality. In Miss Proud's words, "Industry has, at least to some extent, passed through the phase in which a group of workers was looked upon as a mere multiple of a single worker. It is recognised that its members have duties, rights, and desires, as a group and as individuals. To adjust these is a task too delicate to be left to spare moments or the chance interest of the employer. It is gradually becoming recognised as the business of an expert, though it must not be forgotten that the one indispensable quality for its successful accomplishment is tact."

No Sinecure.

Obviously something more than a degree in economics or social science is necessary for an official who is to stand between employer and employed and to interpret the one to the other with perfect freedom and fairness. Unflagging energy as well as wide sympathies are essential, for the welfare work in a large factory is no sinecure, and the path, as of everyone who in any sense of the words tries to serve two masters, is beset with pitfalls. The responsibility, too, is great. The welfare secretary exercises a general supervision over the wages and hours of the workers, their instruction, their health, their recreation, and their savings: he or she is answerable for the discipline of the factory, and for the considerate treatment of the workers. The various ramifications of these duties, and the kind of work entailed by their proper carrying out, I have not space to describe in this article: he who runs may read of it in Miss Proud's book, where the scope of the Welfare Department in any factory is described in the fullest and most interesting detail.

The Maligned Employer.

The chief impression, to my mind, that remains with one after reading the book is surprise at what has already been done, quietly and without undue publicity, by so many employers of labour large and small. It is not so very long, as years go, since the Industrial Revolution, but we have travelled far in those years, and all along the line we see employers, representatives of the hated class from which no good could come, performing the functions of pioneers of progress, despite the obstacles set in their path alike by friends—their compeers, and "foes"—their employees. The stony-hearted "villain of the piece" has been rather the consumer, ignorant of the suffering involved in unrestricted labour, than the employer with the misery always before his eyes. But, with the swamping of the personal relation by force of numbers, the problem becomes even greater for the modern manufacturer, and the man who will lay the industrial world at his feet by solving the difficulties existing between capital and labour is still to be. Meanwhile, to my way of thinking, welfare work properly organised and carried on by a responsible person in such a way that it benefits employer and employed alike, seems to constitute a decided step in the right direction: and with that conclusion everyone who reads Miss Proud's book must, I feel sure, agree.

REVIEWS OF BOOKS.

Welfare Work, by E. Dorothea Proud, B.A., with a foreword by the Rt. Hon. David Lloyd George. (Messrs. G. Bell and Sons, Ltd., London, 1916, 363 *pp.*)

THE book by Miss Proud, referred to in the article by Mrs. Cloudesley Brereton in the preceding pages, is divided into two parts, the former dealing with the principles underlying welfare work in factories and the historical treatment of past work; the latter mainly with administrative details.

The first two chapters analyse the function of the employer in a capitalistic state, and his influence on factory legislation. Following this we have a summary of the trend of industrial legislation as a whole and a sketch of the gradually changing view held by employers on this subject. One drawback, however, to the present development of large companies and big industrial concerns is that the employer tends to lose touch with his men, and it is largely this fact that has necessitated the formation of "welfare departments" to act as a go-between and see that the social and hygienic needs of workers are not overlooked. Gradually the idea is taking shape that such work is not "charity" nor a concession to workers, but a wise mutual arrangement profitable alike to employer and employee.

In Part II. the scope of the Welfare Movement is discussed in detail. We are shown how the industrial environment, the provision of lavatories and cloak rooms, mess rooms, rest rooms, &c., should be studied; and how the physical well-being of workers can be promoted by attention to food, recreation, housing, education, &c.

Finally, there are an appendix in which a considerable amount of varied matter bearing on industrial welfare is assembled, and an adequate index.

A feature of the book is the very full series of references to earlier work which should make it invaluable to students in this field.

We hope that, in a future edition, the author will see fit to devote a special section to *illumination*, which is now regarded as a most important element in the health and efficiency of workers.

Optical Glass, by Walter Rosenhain, D.Sc., F.R.S. (Cantor Lectures delivered before the Royal Society of Arts on November 29*th, December* 6*th and* 13*th,* 1915.)

SINCE the outbreak of war few subjects have been more constantly debated in scientific circles than our deficiencies in the manufacture of optical glass. Dr. Rosenhain's Cantor Lectures on this subject, now published in pamphlet form, are therefore most opportune.

In his first lecture he explains the fundamental properties which distinguish "optical" from ordinary glass, emphasising the need for refinement in the making of colourless media, having a minimum absorption of light. It is important to notice that some forms of "neutral glass" are only obtained by arranging for the respective undue absorption of the pink and green elements in the spectrum to "cancel out," thus securing the neutral quality by undue absorption of light. In an ideal glass neutrality would be secured by correctly transmitting the entire spectrum with no loss of light. Other qualities desirable in optical glass are (1) absence of gas-bubbles and freedom from inequality in structure through the formation of small local crystals, which cause *striæ*. All these qualities require to be tested with minute care.

Of equal importance is the durability of the glass. Some kinds of glass, especially those containing much alkali, are unable to resist the chemical effect of the atmosphere, the surface being readily deteriorated by moisture and carbon dioxide. In practice one must make a compromise between durability and other necessary qualities.

The building up of the optical glass industry in Germany dates from the State-aided researches of Schott and Abbe, at Jena. Germany has also been helped by the fact of there being available sources of very pure sand. We have hitherto been dependent mainly on the sand imported from Fontainebleau, near Paris. A systematic search of the British Dominions might, however, reveal other sources of this material.

Dr. Rosenhain also deals with the various furnaces available for glass work, both gas-, electric-, and coal-heated, and with the process of turning out furnace-pots of good quality.

A question of great theoretical interest is the synthetic building up of materials such as occur in various transparent crystals; possibly in this way qualities hitherto unobtainable in glass, as at present manufactured, might be discovered. It is worth noting that the essential principles employed in the manufacture of optical glass at Jena were known many years ago; no radical departures have been made. There is no inherent reason why optical glass should not be made as well in this country as in Germany. The conditions which enabled that country to take the lead are well understood, but by adequately supported scientific research, and by striking out in new directions and not merely following the lines they have adopted, the whole industry might be placed on a better basis; if this were done the author sees no need for tariffs or subsidies.

But it is to be observed that Dr. Rosenhain questions whether the mere manufacture of optical glass is—even at the present time—commercially profitable. Its real value lies in its possible applications to many vital dependent processes, and in this sense it may fitly be described as a "key-industry" of considerable practical importance

The Theory of the Flicker Photometer, by H. E. Ives and E. F. Kingsbury. (*Phil. Mag., Vol. XXXI., April,* 1916.)

THIS paper is subsidiary to the authors' previous contribution to the *Philosophical Magazine* in 1914. The study of the connection between critical speed and illumination is continued, and the relation connecting these quantities is deduced, namely :—

$$\text{critical speed} = a \log \text{illumination} + b.$$

The high sensibility attributed by the author to the flicker photometer is ascribed to the very rapid increase in the critical frequency of disappearance of flicker on each side of the equality setting. Curves are presented showing this connection. These curves are shown meeting in a cusp at a point on the abscissa, though in practice experience shows that the curves are somewhat rounded at this point; this is presumably due to imperfections in the line of division between the photometric surfaces. It is also stated that imperfections in the flicker surface shift the equality point appreciably, so that such photometers should always be used on the "substitution" or "double-weighing" method.

When one turns to the use of the flicker photometer for lights which differ in colour one finds that the point of balance is affected by various alterations in design. For example, if the period of exposure for the two colours is unequal, that exposed for the shorter time will be under-rated. Even for lights of the same colour the point of balance may be shifted by unequal exposure if the surface of the rotating disc is not optically uniform.

General Electric Review, U.S.A. (*September,* 1916).

THE *General Electric Review* for September contains several articles on illumination. M. Luckiesh, in "THE FUNDAMENTALS OF LIGHTING," emphasises the part played by colour and light and shade in connection with architectural and decorative effects. One point of interest is the relation between the actual variations in brightness and those which may be distinguished by the eye. The adaptation of the eye plays a great part. Thus the variations perceptible out of doors at night may be as much as 10 per cent., whereas, under ideal conditions indoors, a variation of less than 2 per cent. can be detected. In determining the permissible variation in illumination this fact should be borne in mind.

A. L. Powell contributes an illustrated article on "INTERIOR ILLUMINATION," in which a number of specific problems, for example, the lighting of armouries and gymnasiums, show-windows, stores, churches, tennis courts, etc., are discussed.

H. H. Reeves, in "INCANDESCENT STREET LIGHTING REGULATING APPARATUS," weighs the advantages and drawbacks of various types of regulators for constant current circuits.

W. S. Andrews has an interesting note on "SELF-LUMINOUS PAINTS." A most important question is the percentage of radio-active substance which it is desirable to mix with the luminescing sulphide. In general, a higher percentage of the radium element means a greater initial brightness but a shorter life. It is interesting to note that for Army and Navy purposes the United States Government calls for a guarantee of an undiminished luminosity for two years—a requirement that can be met without difficulty.

Reference is also made to other possible sources of radio-activity, such as radiothorium. This has a very intense effect, but its "half-life" is only three to four years. Mesothorium, a by-product of the mantle industry, is now being used on account of its comparative cheapness. There is a difference in opinion as to the relative merits of paint using respectively radium and mesothorium, but both will probably find their appropriate applications in the future.

Publications of the Bureau of Standards (Washington).

THE work of the Bureau of Standards (Washington) affords an excellent example of what can be done by a well-equipped experimental station. The Bulletins cover an exceedingly wide ground, and their free distribution in other countries is an international service. The publicity arrangements are worthy of special commendation, an abstract being furnished with each bulletin so that its contents can be understood at a glance and the chief points appreciated. The work of the Bureau of Standards is of public benefit, and the distribution of information published by it appears to be carried out on a well-organised plan. Accompanying the abstract is a note to the effect that copies of any bulletin will be sent free to any one applying for it, and an effort is made to see that each publication reaches people to whom it will be of value. After so much has been spent on the organisation and equipment of an experimental institution of this kind, the additional expenditure needed to make its work well known and widely recognised appears fully justified. This practice might with advantage be imitated by Government Departments in this country.

As an instance we have before us Bulletin No. 56 on *Standards for Electric Service.* This is a summary of the various steps being taken to promote uniformity of practice on the part of electricity concerns in America, both as regards general local legislation, and such matters as adequacy and safety of electric service, meters and instruments, and standardising laboratories. The contents of the Bulletin occupy upwards of 250 pages, so that the three-page typed abstract provided is welcome. Many of the suggestions made should be of direct interest to electricity companies in this country.

Among other recent publications received from the Bureau of Standards, we note :—

No. 281. *A Study of the Inductance of Four-terminal Resistance Standards.*

No. 283. *Volume Effect in the Silver Voltameter.*

No. 284. *Constants of Spectral Radiation of a uniformly heated Inclosure or so-called Black Body.*

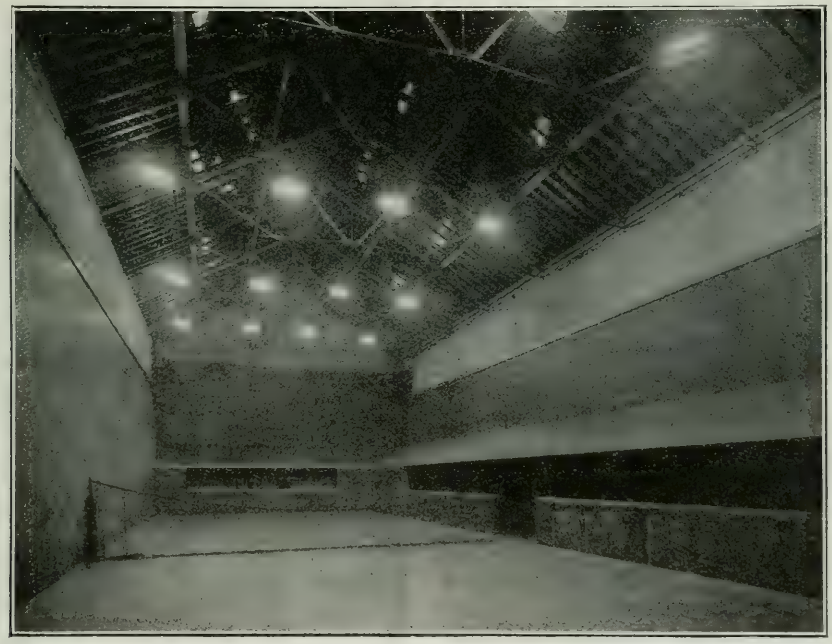
No. 286. *Determination of Aluminium as Oxide.*

THE LIGHTING OF A TENNIS COURT BY MERCURY VAPOUR LAMPS.

In past issues of this journal the Illumination of Covered Lawn Tennis Courts by tungsten lamps, and also by high pressure gas has been described. A somewhat different problem is the lighting of tennis courts, as exemplified by the court at the Prince's Tennis and Racquets Club in Knightsbridge, which has been illuminated by mercury vapour lamps.

Tennis, as distinguished from lawn tennis, is a game that dates back hundreds of years. It is played under somewhat peculiar conditions in a specially constructed court, the floor and walls of which are composed mainly of smooth grey stone. During the daytime the illumination for the court is received from a large skylight occupying the greater part of the ceiling, and thus making it difficult for indirect methods to be used. The grey surroundings naturally render little assistance in diffusing the light, and it is therefore essential to use lamps in which the light is spread out over a large area.

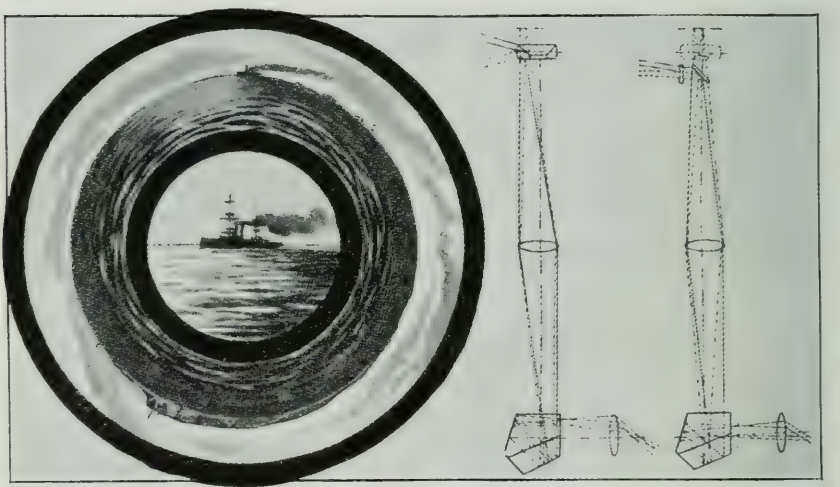
The illustration will give an idea of the lighting of this court. Twenty mercury vapour lamps, each consuming 350 watts and rated at 1,000 c.p. were suspended from the girders at appropriate intervals. The court is approximately 80 feet long and 40 feet broad, so that the consumption works out to about 2·2 watts per square foot. A test of the illumination 3 feet above the floor showed that a fairly uniform value of 3·5–5 foot-candles is provided. In this game the ball travels rapidly round the court and is taken by the players as it bounces from the back walls. It is therefore essential that a person standing with his face to the wall should not cast a dense shadow. A feature claimed for this installation of mercury lamps is that the shadows are exceedingly soft, and no trouble from this source is experienced.



Illumination of Prince's Tennis Court, Knightsbridge, by mercury vapour lamps.

PANORAMIC PERISCOPE FOR SUBMARINES.

THE present war, with its long-range artillery, has emphasised the importance of scientific devices for observing the enemy at a distance. As is well known this faculty is particularly vital in the case of submarines, which observe the character of approaching vessels by means of a periscope, projecting above the surface of the water while the submarine remains submerged.



According to *Popular Mechanics*, in the modern periscope an arrangement is introduced, enabling both a general survey of the horizon and a detailed observation of any particular vessel to be made. This is described as follows :—

One of the great handicaps imposed upon the operators of modern submarines has been the inability to see in more than one direction at a time. Only by turning the periscope, or encircling a "walk round," has it been possible to scan the whole horizon, and then not at a single glance as now.

At the top of the instrument is an annular lens, the exterior of which has a spherical curvature while the interior is ellipsoidal. Images of everything discernible about the whole horizon are first refracted and then reflected down the tube. They are collected in a horizental plane by a condenser set midway in the tube, and thrown upon a five-sided prism at the bottom which reflects the rays twice and projects them through the binoculars. The view given the observer is circular ; much the same in appearance as if he were looking at one side of a globe.

This describes one-half of the instrument, which in reality is a double periscope. Immediately below the lens at the top of the tube is a second eye, and this may be turned in any direction and focused on a specific object, just as an ordinary periscope may. The rays entering it pass down the tube in the same manner as the others, but without interfering with them. The image appears in the centre of the panoramic picture and is greatly magnified in comparison with individual objects shown in the latter.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

RAILWAY LIGHTING.

We have received from **Holophane Ltd.** a booklet describing the applications of Holophane units to various problems in railway lighting, such as the illumination of platforms, booking halls, offices, coaches, &c. The booklet is illustrated by photographs of installations on many of the London railways, and all the chief types of Holophane glassware are seen in operation. There are also some installation data and particulars of indoor and outdoor industrial units, adapted for half-watt lamps and particularly suitable for goods yards, sidings, &c.

MAZDA LAMPS.

A recent list issued by the **British Thomson-Houston Co., Ltd.,** gives particulars of the latest types of Mazda drawn wire lamps. In addition to the standard types, ordinary and gas-filled, for voltages of 100—130 and 200—255, 25-volt lamps ranging from 15—100 watts are mentioned as being particularly suitable for train-lighting, in country houses, and for use with auto-transformers. In addition, "candle," "mazdalite," and other special types are illustrated.

Supplementary sheets dealing with half-watt and battery and automobile lamps have also been issued.

EDISWAN ITEMS.

Among various articles described in booklets received from the **Edison and Swan Electric Co., Ltd.,** is the Ediswan "Esco" Buzzer, which, owing to its compactness, can replace an electric bell with advantage for many purposes. By means of a screw adjustment twelve distinct tones can be obtained.

Another pamphlet deals with the Ediswan "Hosgood" stoneware electric utensils, such as boiling jugs, shaving pots, sterilisers and food warmers, &c. The smaller vessels will take 1—2 pints of liquid, which can be raised to boiling heat in 3 to 10 minutes, according to the capacity.

An interesting item is the Ediswan "H_2O" cell, which is intended to fulfil the functions of the Leclanché, but is smaller and more compact. This cell only requires the addition of water for charging, and, it is stated, can be stored for any length of time and in any climate without deterioration. Other advantages claimed are that it is not liable to creeping or evaporation whilst in use, that its internatal resistance is low, and that it does not polarise in use so readily as wet batteries of the "Leclanché" type.

SHADES FOR SUBDUED INTERIOR LIGHTING.

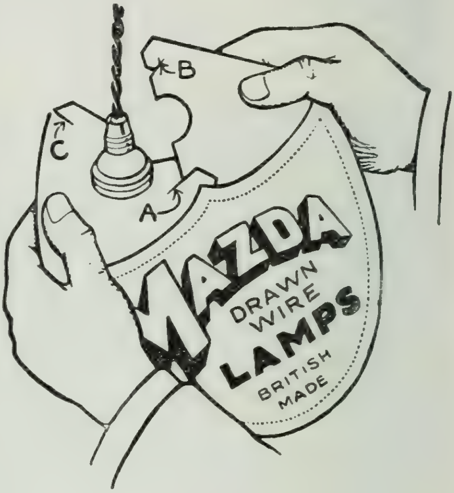
The more stringent regulations recently issued for the diminution of private lighting make it necessary for the consumer to exercise his ingenuity in preventing light straying out into the street; the present conditions have probably led him to study lighting more closely than he ever did before.

Undoubtedly the most important requirement is substantial blinds, through which little, if any, light can penetrate. If good opaque blinds are used little interference with the usual system of lighting will be necessary. In any room where a good general illumination is essential—for example, a workroom with operations going on over the entire floor—this way of meeting the problem may be strongly recommended.

In any case there should be no chinks through which *direct* light can pass. But it is often possible, at least in inland towns where the lighting regulations are not so severe as on the coast, to retain the existing curtains, even though they allow a little diffused light to penetrate outwards, provided the lamps in the room are suitably screened. The consumer who already uses a well shaded system of lighting, with most of the light thrown downwards, is here at an advantage. With light green casement curtains acceptable conditions can usually be produced, provided no direct light from the source reaches the curtains. A Holophane reflector with a silk or paper shade superimposed over it answers the purpose very well.

In shop-windows lamps must be screened in directions facing the street, and in addition to this it is usually necessary to diminish even the light reflected from the goods. This should be done as far as possible by using fewer lamps or lamps of smaller candlepower, not by the clumsy and occasionally dangerous practice of surrounding them with crinkled coloured paper.

Several of the firms interested in lighting appliances have turned out cardboard shades, which serve as advertisements, and answer the purpose of screening the lamps from outside view. The illustration shows a typical shade of this kind supplied free by the British Thomson Houston Co., Ltd.



The shade is posted flat, and is made up of stout dark coloured card, with stencil cut-out lettering, backed by orange tinted paper. From the accompanying illustration it will be seen that the shade can be placed over any electric lamp without removing the latter, while if an ordinary fancy glass shade is used, the "Mazda" shade will go over it. To place the screen in position, the two wings are locked together around the holder, this movement causing the shade itself to assume a curved form, thus shutting off the direct light rays from about one-third of the circumference of the lamp. The wings are locked in the following manner. The right-hand wing is first inserted in the slit (A) provided in the other wing, the hooked end of the wing (B) being then held in a second slit (C). In this way the wings are held rigidly and the shade cannot fall off, or open out accidentally. The lettering shows up with a warm tint by transmitted light, and while shutting off all direct light in front, permits of ample illumination behind. By daylight the wording is also clearly outlined by reflected light.

A BRITISH TRADE BANK.

A most important series of recommendations are made in the Report just issued by the Committee under the chairmanship of Lord Farintosh, dealing with national financial facilities for trade.

It is recommended that a "British Trade Bank" should be constituted under Royal Charter. The chief features of the proposed bank would be as follows :—

(1) It should have a capital of £10,000,000. The first issue should be from £2,500,000 to £5,000,000, upon which, in the first instance, only a small amount should be paid up, but which should all be called up within a reasonable time. A further issue should be made afterwards, if possible at a premium.

(2) It should not accept deposits at call or short notice.

(3) It should only open current accounts for parties who are proposing to make use of the overseas facilities which it would afford.

(4) It should have a foreign department, where special facilities might be afforded for dealing with bills in foreign currency.

(5) It should open a credit department for the issue of credits to parties at home and abroad.

(6) It should enter into banking agency arrangements with existing Colonial or British foreign banks wherever they could be concluded upon reasonable terms, and where such arrangements were made it should undertake not to set up for a specified period its own branches or agencies. It should have power to set up branches or agencies where no British-Foreign bank of importance exists.

(7) It should inaugurate an information bureau.

(8) It should endeavour not to interfere in any business for which existing banks and banking houses now provide facilities, and it should try to promote working transactions on joint account with other banks, and should invite other banks to submit to it new transactions, which, owing to length of time, magnitude, or other reasons, they are not prepared to undertake alone.

(9) Where desirable, it should co-operate with the merchant and manufacturer and possibly accept risks upon joint account.

(10) It should become a centre for syndicate operations, availing itself of the special knowledge which it will possess through its Information Bureau.

(11) It should reeevie Government assistance.

It is suggested that the Bank should be formed without delay in order to be in operation by the time the war is over, when many opportunities for exercising its functions will arise. It is expected to be particularly helpful in financing overseas contracts and in assisting the considerable number of educated young men, who, at the conclusion of the war, will desire to open up new commercial fields in foreign countries.

The proposed Information Bureau, or "Bureau d'Etudes," should also be of great service in collecting statistics and information of value to the leading industries of the country.

HALF-WATT LANTERNS AND FITTINGS.

In too many cases fittings intended originally for use with one or more ordinary tungsten lamps of low candlepower, have been converted for use with a single high candlepower half-watt lamp. As a rule such devices do not give good results. The half-watt lamp requires special treatment with a view to getting satisfactory distribution of light. Moreover, in view of the greater heat produced, many methods which answered satisfactorily under the old conditions are not advisable when gas-filled lamps are employed.

We notice that **Messrs. Crompton and Co., Ltd.,** are producing a series of specially designed half-watt lanterns and fittings, of which the type shown in the adjacent illustration is an example. Such undesirable features as the use of clamping screws on the rim of the globe, or rubber rings or perishable packing materials, have been avoided. The fitting is equipped with separate panes of fluted glass (muranese or other types can also be used), thus facilitating renewal of broken glass at a low cost. The structure of the fittings is such as to concentrate the light in a useful downward direction, and by using appropriate glass the high intrinsic brilliancy of the half-watt lamp can be reduced without serious loss of light.

The fitting shown is intended for lamps up to 1,500 watts. In cases when lamps are run on an alternating circuit a small transformer can be fitted into the lantern, and on installations where diminished lighting is at present necessary a second holder, carrying a lamp of comparatively low candlepower, can be supported below the larger one.

MANUFACTURE OF BENJAMIN REFLECTORS.

Under the title "A Question of Origin," **The Benjamin Electric, Ltd.,** have issued a neat booklet descriptive of the manufacture of Benjamin Reflectors and other accessories, as carried on at the works in Rosebery Avenue, E.C. The booklet is illustrated by photographs showing the various processes in operation, including the stamping out of reflector-shapes under the big double-action press, the enamelling, special work in the tinsmith's shop, &c.

It will be recalled that a description of these processes was given in our issue for June, 1916. The main object of the booklet is to demonstrate, by actual photographs, the production of Benjamin Reflectors and other specialities at the Company's Workshops in London.

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Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

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Signature ....

This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

LIGHTING OF HOTELS AND RESTAURANTS.

A recent addition to the Holophane series of booklets deals with various phases of lighting in hotels and restaurants. There are photographs of a variety of installations, ranging from a small bar to a large restaurant. Some particulars are also given of Reflector Bowls, "Residence" reflectors, and other appropriate units for this class of work. From time immemorial the light of the distant hostel have cheered the traveller. At present, in view of the prevailing darkness outside, cheerful indoor illumination is all the more welcome.

—o—

TILLEY HIGH PRESSURE GAS METAL FURNACES.

While the interest of our readers in high pressure gas is centred mainly on lighting problems, it should not be forgotten that heating with high pressure gas is now playing an important part in many industrial operations, for example, in furnaces for metallurgical work. A very compact form is the Tilley Metal Furnace for melting lead, zinc, tin, antimony, etc. One advantage of gas-heated furnaces of this description is that the gas is readily controlled, and the temperature easily kept at the right value.

—o—

CALORIFIC STANDARD FOR GAS.

In his recent address before the North British Association of Gas Managers, Mr. Masterton referred to the advisability of establishing a calorific standard for gas. A reduction in candlepower affects mainly consumers using flat-flame burners, who number only 15—20 per cent. (or less) of the total consumers. If a calorific standard is adopted permanently the bulk of the consumers would benefit, and it seems unfair to the majority to keep back a progressive movement merely because a small percentage of consumers would be adversely affected.

—o—

BIRMINGHAM CHAMBER OF COMMERCE—£50,000 DEVELOPMENT SCHEME.

A scheme has been set on foot by the Birmingham Chamber of Commerce for the establishment of a "House of Commerce" to act as a centre for industrial development in Birmingham. In the future it is hoped to investigate such questions as Transport, Publicity, and Preparation of Statistical Data, European, Colonial and South American Trade. The proposed House of Commerce will form part of a development scheme, for which £50,000 is needed, to deal adequately with all these matters.

—o—

EDUCATION NOTES.

THE POLYTECHNIC.

We have received from THE POLYTECHNIC (Regent Street, London) particulars of the COURSES IN ENGINEERING AND MECHANICAL SCIENCE, to be given during the winter session, 1916. Besides general mechanical engineering, such subjects as motor-car management and inspection, aero engineering, and power plant design are included.

In view of the growing recognition of the benefits of technical education, it is encouraging to see that such evening classes are being persevered with, even in the present difficult circumstances. There must be many men engaged in engineering occupations during the day time who could better themselves by acquiring such special knowledge in their leisure time, and in the future we do not doubt that they will reap the benefit of their foresight in this respect.

The classes commence on October 2nd, and enrolment may take place from the 25th—29th of September.

THE NORTHAMPTON INSTITUTE

We are glad to see that in spite of the disturbance caused by the war, the Northampton Institute is making a creditable effort to maintain their useful work. We note that the Evening Session starts on September 5th, and the Day Courses Entrance Examinations on September 26th—27th, the Session commencing on October 2nd.

The prospectus contains particulars of varied courses in engineering, such as Automobile Work, Aeronautics, Radio-Telegraphy, and Technical Optics, of which the Northampton Institute has made a special feature. In view of the urgent need for skilled workers in this glass industry we hope that this last course will be well patronised.

We notice that during the past year some useful additions to the plant in the Electrical and Mechanical Engineering Departments have been made.

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Edited by
LEON GASTER

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EDITORIAL.

The Visit of the Circle of Scientific, Technical, and Trade Journalists to the Universities of Leeds and Sheffield.

During the present year the Circle of Scientific, Technical, and Trade Journalists has been actively interested in the study of technical education and industrial research, and in promoting co-operation between those interested in these important subjects. It will be recalled that a very comprehensive paper was read before the Circle by Dr. William Garnett early in the year, and, as a result of the discussions which followed, an invitation was extended to the Circle by the Rt. Hon. Arthur Dyke Acland to visit the Imperial College of Science on May 31st. Mr. Acland, in addressing his guests, expressed the hope that the visit would mark the beginning of closer relations between the Universities and the Press.

The precedent set by the Imperial College has now been followed by the Universities of Leeds and Sheffield, which invited the Circle, as the section of the Institute of Journalists chiefly interested in these matters, to form a party to visit these cities on October 8th—10th. On pp. 315-322 we give a complete account of the proceedings.

The party, who were the guests of the Universities throughout, found the visit a most enjoyable and instructive experience. An interesting feature was the series of visits to various local factories, selected to represent as far as possible industries with which the work of the Universities is associated.

In passing through the special departments of the Universities, devoted to such subjects as organic and tinctorial chemistry, leather and textile work, metallurgy, &c., all were struck by the excellent and in many respects unique facilities provided for research. It is lamentable to think that the depletion of staff and students through the war inevitably interferes with the development of much of this work ; fortunately the present conditions have also opened up new opportunities for national service.

Yet these Universities, while aiming at a close connection with industry, do not lose sight of the higher fundamental elements in education, which are essential in any scheme of training intended to produce men capable of taking a broad human outlook on problems of the present day. This was particularly well illustrated by Mr. Sadler's admirable and inspiring address, in which the claims respectively of the humanities and of technical and purely scientific knowledge were balanced. Mr. Sadler showed, too, how the constitution of Leeds University, receiving endowments and funds both from the State and from local sources, is admirably adapted to the preservation of this dual aspect of education. The support of local manufacturers, authorities, and institutions, and the deep interest which they take in the welfare of the University places it in a position to do full justice to the claims of local industries ; but at the same time the relation with the State enables it also to mould its courses of study so as to be adapted to broader national requirements.

On the various advisory committees which assist the work of the different departments, academic and business interests are well balanced, and such co-operation must have a beneficial influence on the work of the University. But it will be generally agreed that leading educational institutions should be free to mould their system of education without undue commercial or political control ; freedom in this direction can be safeguarded by the distribution of funds so that the University is not entirely dependent on any one source of endowment.

The atmosphere of these northern cities is somehow suggestive of vast industrial activity and of new forces struggling for expression. Those who have not recently visited Sheffield, for example, can form no adequate conception of the immense area covered by the great armament firms, still spreading and expanding and producing in works standing on ground that was open fields but a few months ago. At present the energies of these firms are naturally concentrated on the production of war material, but it is obvious that after the war there will be great opportunities for their conversion to new fields of industry, and for the application on a far larger scale than at present of scientific knowledge and method.

Another thing that struck the visitors was the keen interest and pride felt by the cities of Leeds and Sheffield in the work of their Universities. In the past the support given to those institutions has been on a generous scale. We hope and believe that in the present circumstances, when there is in some quarters a tendency to " economise " over education, these cities will live up to their past record and see that the work of the Universities is not hampered by insufficient funds, and that in the future even greater support will be available for the expansion of their valuable activities.

We notice that in the course of last year, when there seemed to be some danger of undue economies in this direction, the Universities of Manchester, Liverpool, Leeds, and Sheffield took common action, and presented to the Committee on Public Retrenchment a Memorandum summarising the activities of the Universities, expressing the hope that their work would not be allowed to suffer. We understand that the Universities are in constant touch with each other, and that their courses of study and examinations are arranged on similar lines. Doubtless such concerted effort will enable these Universities to exert a powerful influence on behalf of education. We were glad to observe that some of the leading manufacturers appreciate the advantage of securing technically trained men from the Universities. It is evident that appropriate salaries must be obtained in order to retain men of the right class, ond after the war the demand may exceed the supply.

At the present time, when we are all distracted by the war, it may be difficult to organise great extensions in technical education. But we can at least prepare public opinion for the great educational expansions that will undoubtedly become necessary after the war, and here the Scientific and Technical Press can do most valuable work. As yet the public has hardly grasped how great must be our efforts and how generous the nation's contribution to educational centres in the future if we are to make up the leeway of the past.

In dwelling on these things, however, there is no need to strike a despondent note. Conscious as we are of the vast amount that remains to be done, it is an encouragement and a stimulus to further effort to turn our eyes in directions where the good fight is making progress, and to let the country know what is being done even now in our midst. To many of the party the possibilities in the work of the Universities of Leeds and Sheffield came as a revelation. Here at least the torch of science is being kept alight, and only needs judicious replenishment to burst into new splendour after the war.

A very pleasant feature was the co-operation of the local Press, who joined in welcoming the visitors on their arrival in Leeds, and took part in the visits, and who, in their subsequent reports of the proceedings, paid a well-merited tribute to the work of the Universities. Their much-appreciated action in this respect is typical of the co-operation we should like to see established between the daily Press and their brethren in the scientific and technical sphere in keeping the important subjects of technical education and industrial research before the notice of the nation.

In conclusion, we should like to express our deep appreciation of the enterprise of the Universities in arranging this visit, and of the great amount of trouble taken by the Vice-Chancellors and the Professors in making the trip enjoyable and instructive. Everything possible was done for their comfort. A word of acknowledgment is due to Mr. Wheeler, the Secretary of Leeds University, on whom fell much of the work in making the preliminary arrangements for the visit to Leeds. Thanks are also due to the Midland Railway Co., who made special arrangements for the comfort of visitors on their journey.

Illuminating Engineering in the United States.

On pp. 305—308 we give a summary of the proceedings at the Tenth Annual Convention of the Illuminating Engineering Society in the United States. As usual the papers covered a wide variety of topics, and the Convention this year must have been rendered particularly interesting by the fact of a series of lectures on illuminating engineering being given at Pennsylvania University, and the visits to local installations arranged in connection therewith.

An interesting address was delivered by the new President, Dr. C. P. Steinmetz, who dealt with the fascinating problem of the efficiency of light production, as illustrated by modern illuminants. Future progress, Dr. Steinmetz pointed out, must lie mainly in the direction of the fuller utilisation of the principle of luminescence. A high efficiency can only be expected from processes involving the transformation of energy from a high form to a low one. In the case of solids brought to incandescence by the action of heat there is inevitably considerable loss. In those illuminants using electro-luminescence a somewhat better result may be expected, but we are still far from the theoretically attainable efficiency of 300—400 lumens per watt.

Many of the other papers and addresses dealt with practical problems. Mr. L. B. Marks, for example, referred to the tendency to greater precision in industrial lighting, as exemplified by the action of the States of Pennsylvania and New Jersey in accepting a Code of Factory Lighting, based on the provision of illumination requirements in terms of foot-candles. This enterprising action appears to be a direct result of the excellent pioneering work recently carried out by the Illuminating Engineering Society in the United States, and will no doubt be followed by other States. On p. 324 we give a summary of the Pennsylvania Code, which, in its general lines, is in close agreement with the Report of the Home Office Departmental Committee in this country.

Among the other varied subjects discussed at the Convention we notice several papers on the projection of light, and it is satisfactory to note that this subject is now receiving the attention of lighting engineers. It is not sufficiently recognised how low is the efficiency of the optical lantern, the cinematograph, and other similar apparatus. According to Mr. Chillas only about 5—8 per cent. of the light from the source actually reaches the screen. There is therefore vast room for improvement. Photometric problems also received a fair share of attention. The use of the integrating sphere has made considerable progress in the States, and its possibilities and defects are becoming better understood. It appears that such apparatus, while giving a fair measure of accuracy in skilled hands, needs to be used intelligently.

Yet another section of illuminating engineering where good work is being done is the study of brightness and its effect on the eye. The series of figures given by Mr. P. G. Nutting show how closely such results are associated with the state of adaptation of the eye—a circumstance which has perhaps hardly been sufficiently appreciated by students in the past.

We are also glad to see that the series of lectures following the Convention was well attended, and we shall look forward with interest to the printed report which will doubtless furnish a valuable record of present practice in the United States.

LEON GASTER.

NOTES ON THE TENTH ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

(Held in Philadelphia, September 18th—20th, 1916.)

In a previous issue we presented a list of the papers to be read at the Tenth Annual Convention of the Illuminating Engineering Society in the United States. In the following notes we propose to give a summary of the proceedings and of the contents of these papers. The Convention was attended by nearly 500 delegates representative of different phases of the lighting industry; special interest was aroused by the series of lectures arranged at Pennsylvania University, following immediately after the Convention, and including a tour of the chief lighting installations in the district.

PRESIDENTIAL ADDRESS.

After a welcome had been accorded to the visitors by Mr. E. B. Cattell, chief city statistician of Philadelphia, an address was delivered by Dr. C. P. Steinmetz, the new president. Dr. Steinmetz, in summarising recent progress in illuminants, expressed the view that the most hopeful prospect of approaching the ideal efficiency, computed at 300—400 lumens per watt, lay in the utilisation of luminescence. The luminous arc, with an efficiency of approximately 100 lumens per watt (0·12 watts per candle), furnished one of the best examples of such an illuminant. In general a high efficiency could only be anticipated if energy were transformed from a high form to a low one. If one relied on the converse operation, as in the case of solids heated to incandescence where heat is converted into light, the process was invariably comparatively inefficient.

Dr. Steinmetz also described some of the investigations now in progress with a view to obtaining still higher efficiencies from the luminous arc. These include a survey of the spectra of the vapour of all known elements, under varied conditions of electrode temperature and pressure. Most of our present information is based on phenomena which take place at ordinary atmospheric pressure; but it is well known that marked variations occur when the pressure is greatly increased or diminished. For example, the mercury vapour lamp, whose ordinary predominant tone is green, becomes pinkish when superheated mercury is used, and violet at very low temperatures and pressures.

As an instance of other possible directions of research, Dr. Steinmetz mentioned the luminescence of willemite under cathode bombardment; in electroluminescence the physicist has an energy-conversion of the highest efficiency but a really satisfactory method of applying the exciting energy has still to be obtained.

REPORT ON PROGRESS.

The usual report is presented by the Committee on Progress, occupying 60 pages of densely-printed matter. A list of symbols and definitions of terms used in illuminating engineering has been prepared by the Committee of Nomenclature and Standards. These are reproduced on pp. 309—313 in this issue.

PROJECTION PROBLEMS.

Two papers, by J. A. Orange and R. B. Chillas, deal with the designs of apparatus for optical projection, such as the searchlight and the magic lantern. The formula for the illumination of the screen is as follows:—

$$I = \frac{B.A}{x^2}.k,$$

where B is the intrinsic brilliancy of the source, A the apparent opening of the objective, x the distance of projection and k the coefficient of transmission of the system. From this it is apparent that the most important factor in the source of light is high intrinsic brightness. The coefficient of transmission of the system is exceedingly low. R. B. Chillas estimates that only 10—12 per cent. of the light yielded by the arc crater strikes the condenser in the lantern, and that the percentage of the original light reaching the screen is under 5—8 per cent. In a searchlight, using a parabolic mirror, on the other hand, about 60 per cent. of the total flux of light is received by the mirror. He therefore asks whether elliptical mirrors, with the source at one focus and the objective at the other, could not be used for lantern projection, believing that a higher efficiency might conceivably be obtained in this way.

In practice it is necessary to compromise between the best arrangements of lens and source. One may :—

(1) Use a very small objective, an ordinary condenser and a powerful and expensive source.

(2) Use a small objective, an expensive condenser and a small cheap source of light.

(3) Use an objective which has a gross aperture in excess of the effective aperture for any field point, a cheap condenser, and a relatively small and cheap source.

Mr. Orange summarises the figures so far given for the illumination of cinematograph screens ; 2·5 ft.-candles seems a desirable figure.

A paper by H. P. Gage, on "Coloured Glass in Illuminating Engineering," contains some curves showing the distribution of light in the spectrum from typical glasses of so-called pure colours (red, green, &c.). A reference is also made to glass for the obstruction of ultra-violet light, fluorescing glass, and amber glass to relieve eyestrain. It is sometimes held that the latter glass improves acuity of vision, but the author prefers the full spectrum of white light. An "artificial daylight" screen for use with the half-watt lamp is now available ; this is stated to transmit about 15 per cent. of light.

PHOTOMETRY WITH THE INTEGRATING SPHERE.

An interesting paper was read by F. A. Benford on "The Integrating Sphere and a New Type of Compensating Screen." It is pointed out that in an integrating sphere errors are caused by the presence of "foreign bodies" such as the screens inserted to protect the observation window from the direct rays of the lamp tested or from the calibrating source. Errors may also be caused by the absorption of light by the actual lamp tested. These errors are most observable with spheres of small diameter ; when the diameter attains two metres or over they are of less account. The author suggests a special form of screen to compensate these effects. This consists of a small convex mirror, with the reflecting surface facing the window, whose position is so adjusted that the hemisphere in which the window is located is now entirely visible from the window ; there are thus two distinct paths by which rays from the interior surface of the sphere reach the window : (a) directly, and (b) by reflection from the convex mirror. A refinement which adds to the efficacy of the device consists in painting sections of the mirror-surface with black paint. In this way, it is claimed, the errors due to foreign bodies are diminished and the effect of unsymmetrical distribution of light from the source tested is much less noticeable.

FORCED LIFE TESTS.

L. J. Lewinson discusses the value of forced life tests on incandescent lamps, *i.e.*, tests in which the lamps are intentionally run at a higher efficiency than normal so that the diminution in candle-power takes place more quickly. Such tests lead to a considerable saving in time but have to be made as carefully as ordinary life tests. It is known that the results by forced and ordinary life tests can be related thus :—

$$\frac{\text{Life}_1}{\text{Life}_2}=\left(\frac{\text{lumens per watt}_2}{\text{lumens per watt}_1}\right)^b$$

The exponent b was assumed prior to 1914 to have the value 6·65, but this does not appear to apply to all types of lamps and the author, as a result of extensive tests, presents figures varying from 5·6 to 8.2. There is a general tendency towards a lower component for lamps of smaller sizes. The errors involved in assuming a fixed exponent are represented in a diagrammatic form.

BRIGHTNESS RELATIONS.

Several papers dealing with "brightness" in various aspects were read. P. G. Nutting, in his paper on "Brightness and Contrast in Vision," analyses the conditions over the whole range of brightness, the three most important factors being: (1) the lowest perceptible brightness, (2) the faintest perceptible contrast, and (3) the highest comfortable brightness.

These data are conveniently assembled in tabular form thus:—

	Brightness of Field (millilamberts).	Difference Fraction.	Discrimination Faotor.	Threshold Limit (millilamberts).	Glare Limit (millilamberts).
	0·000001	(1·00)	1·0	0·00000093	20·1
	0·00001	(0·66)	1·5	0·0000042	40·7
	0·0001	0·395	2·5	0·000019	89·0
Exteriors at night	0·001	0·204	4·5	0·000087	186·0
	0·01	0·078	12·8	0·00039	400·0
Interiors at night	0·1	0·370	27·0	0·00174	810·0
					Lamberts.
	1·0	0·0208	48·2	0·0081	1·66
Interiors by day	10·0	0·0174	57·5	0·036	3·47
	100·0	0·0172	58·1	0·28	7·25
Exteriors by day	1000·0	0·0240	41·7	2·15	14·45
	10000·0	(0·048)	(20·9)	(232·0)	30·90

One of the most important quantities is the "Discrimination factor," defined as the field brightness divided by the just noticeable brightness (B/dB). It is seen that this reaches a maximum value of 50—60 as the brightness rises; but after a certain point glare sets in and the figure begins to fall again. Similarly, the order of brightness which causes perceptible glare (glare limit) and the least brightness which the eye can detect as light (threshold limit) continuously rise as the eye becomes adapted to each rising step in the general brightness level. L. T. Troland, in "Apparent Brightness: its Conditions and Properties," points out that while a fair measure of precision has been reached in determining the objective brightness of surfaces, no one has yet been able to solve the complexities involved in the problem of measuring the subjective brightness, *i.e.*, the brightness of an object as the mind actually conceives it. The "retinal brightness" depends on at least 30 different factors. An interesting curve is shown by the author connecting the duration of a retinal "after-image" with the period of pre-exposure. In view of the suggestion that the study of such images might furnish a method of estimating glare, this curve is of interest.

Another aspect of the problem is attacked by F. C. Caldwell, who has made the experiment of changing from direct to indirect light (the observer meantime having his eyes closed) and then asking for a judgment whether the illumination is greater or less in one case than the other. While the results are mainly inconclusive, it is interesting to note that five out of seven observers asked for a higher actual illumination by the indirect lighting than by the direct lighting, in order to get the same mental effect.

Dr. C. E. Ferree and Miss G. Rand, whose previous papers have been concerned with the effect of gradation of brightness in the field of vision, give the results of some experiments on a series of six reflectors of various densities; these serve to confirm the views previously expressed as to the effect of bright surfaces on clearness of vision.

BOWLS AND REFLECTORS.

J. L. Stair and J. A. Hoeveler emphasise the value of upper reflectors in connection with translucent bowls—especially in modifying the distribution of light and diminishing the glare that would otherwise be obtained from half-watt lamps. H. W. Jenkins and G. W. Roosa (" Recent Developments in Prismatic Glassware ") likewise referred to the development of glassware for these lamps, special attention being called to the latest bowls of a decorative type.

MISCELLANEOUS.

A very interesting report is presented on the Lighting of the Cleveland Museum of Art by " artificial daylight " units. S. G. Hibbenal analyses the costs of lighting a large office, dealing incidentally with the problem of illuminating elevators. C. S. Snyder and F. H. Gilpin describe the gas-lighting of the Philadelphia Civic Exhibition, a feature of which was the extreme uniformity of the illumination obtained, while C. H. French and C. J. van Gieson advocate the adoption of a combination of gas and electric lighting in the home, the best method of dealing with halls, dining and drawing rooms, bedrooms, &c., and other typical rooms being discussed in detail.

CONDITIONS OF ILLUMINATION IN NEW YORK BUILDINGS.

In the exhaustive inquiries which have been made by many social workers into the conditions in tenements and large city buildings, one has often been struck by the absence of any data regarding the lighting conditions. It is therefore interesting to note in a recent bulletin issued by the Department of Health in New York, an account of an inspection of a large block of buildings in that city, which included an inquiry into the conditions of illumination. It is remarked that in the offices visited as many as 85·33 per cent. of the employees worked by artificial light (it seems to be implied *exclusively* by artificial light). The proper arrangement of the illumination is therefore a matter of importance.

The inspector (Dr. Marion B. McMillan) was struck by the fact that, while æsthetic effects in lighting were evidently the subject of much study and great skill was sometimes shown in the application of expensive lighting fittings, very little attention had been given to *the physiological effect of the illumination.* The amount of illumination varied from 0·5 to over 40 ft.-candles ; there appeared to be no recognised standard although the requirements in different offices were apparently substantially the same. It was considered that for type writing and bookkeeping as much as 8—9 foot-candles was desirable, the best results being obtained from desk-lights, well shaded and placed about 19 inches from the work. There is evidence that very much higher illuminations, such as occur when 40 and 60 watt lamp local lamps are used for desk lighting, affected the eyes prejudicially. Cases are recorded in which the use of glasses began when the workers first began to do their work by artificial light. An interesting case was that of a bookkeeper who suffered from headaches which were traced to the excessive illumination (about 18 ft.-candles). When this was reduced to 7 ft.-candles the headaches disappeared.

The concentration of light on a small area, with comparatively dark surroundings, is regarded as highly prejudicial and local lighting requires to be used with care.

It can hardly be doubted that a similar inspection of offices in this city would be productive of similar comments. At the present time, when economy in lighting is being urged on national grounds, this matter may be commended to the notice of the medical profession.

SYMBOLS, TERMS, AND DEFINITIONS USED IN ILLUMINATING ENGINEERING.

Presented by the Committee on Nomenclature of the Illuminating Engineering Society, U.S.A., September 18th, 1916.

Definitions.

1. **Luminous Flux** is radiant power evaluated according to its visibility; *i.e.*, its capacity to produce the sensation of light.

2. **The visibility,** K_λ of radiation, of a particular wave-length, is the ratio of the luminous flux to the radiant power producing it.

3. **The mean value of the visibility,** K_m, over any range of wave-lengths, or for the whole visible spectrum of any source, is the ratio of the total luminous flux (in lumens) to the total radiant power (in ergs per second, but more commonly in watts).

4. **The luminous intensity,** I, of a point source of light is the solid angular density of the luminous flux emitted by the source in the direction considered; or it is the flux per unit solid angle from that source.

Defining equation:

$$I=\frac{dF}{d\omega}$$

or, if the intensity is uniform,

$$I=\frac{F}{\omega},$$

where ω is the solid angle.

5. Strictly speaking no point source exists, but any source of dimensions which are negligibly small by comparison with the distance at which it is observed may be treated as a point source.

6. **Illumination,** on a surface, is the luminous flux-density on that surface, or the flux per unit of intercepting area.

Defining equation:

$$E=\frac{dF}{dS},$$

or, when uniform,

$$E=\frac{F}{S},$$

where S is the area of the intercepting surface.

7. **Candle**—the unit of luminous intensity maintained by the national laboratories of France, Great Britain, and the United States.*

8. **Candlepower**—luminous intensity expressed in candles.

9. **Lumen**—the unit of luminous flux, equal to the flux emitted in a unit solid angle (steradian) by a point source of one candlepower.†

10. **Lux**—a unit of illumination equal to one lumen per square meter. The cgs. unit of illumination is one lumen per square centimeter. For this unit Blondel has proposed the name "Phot." One millilumen per square centimeter (milliphot) is a practical derivative of the cgs. system. One foot-candle is one lumen per square foot and is equal to 1·0764 milliphots.

The milliphot is recommended for scientific records.

11. **Exposure**—the product of an illumination by the time. Blondel has proposed the name "phot-second" for the unit of exposure in the cgs. system. The microphot second (0·000001 phot-second) is a convenient unit for photographic plate exposure.

12. **Specific luminous radiation, E′**—the luminous flux-density emitted by a surface, or the flux emitted per unit of

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* This unit, which is used also by many other countries, is frequently referred to as the international candle.

† A uniform source of one candle emits 4π lumens.

emissive area. It is expressed in lumens per square centimeter.

Defining equation :

For surfaces obeying Lambert's cosine law of emission,

$$E' = \pi b_0.$$

13. Brightness, b, of an element of a luminous surface from a given position, may be expressed in terms of the luminous intensity per unit area of the surface projected on a plane perpendicular to the line of sight, and including only a surface of dimensions negligibly small in comparison with the distance at which it is observed, It is measured in candles per square centimeter of the projected area.

Defining equation :

$$b = \frac{dI}{dS \cos \theta}.$$

(where is the angle between the normal to the surface and the line of sight.)

14. Normal brightness, b_0, of an element of a surface (sometimes called specific luminous intensity) is the brightness taken in a direction normal to the surface.*

Defining equation :

$$b_0 = \frac{dI}{dS},$$

or, when uniform,

$$b_0 = \frac{I}{S}.$$

15. Brightness may also be expressed in terms of the specific luminous radiation of an ideal surface of perfect diffusing qualities, *i.e.*, one obeying Lambert's cosine law.

16. Lambert—the cgs. unit of brightness—the brightness of a perfectly diffusing surface radiating or reflecting one lumen per square centimeter. This is equivalent to the brightness of a perfectly diffusing surface having a coefficient of reflection equal to unity and an illumination of one phot. For most purposes, the millilambert (0·001 lambert) is the preferable practical unit.

A perfectly diffusing surface emitting one lumen per square foot will have a brightness of 1·076 millilamberts.

Brightness expressed in candles per square centimeter may be reduced to lamberts by multiplying by $\pi = 3 \cdot 14$.

Brightness expressed in candles per square inch may be reduced to foot-candle brightness by multiplying by the factor $144\pi = 452$.

Brightness expressed in candles per square inch may be reduced to lamberts by multiplying by $\pi/6 \cdot 45 = 0 \cdot 4868$.

In practice, no surface obeys exactly Lambert's cosine law of emission ; hence the brightness of a surface in lamberts is, in general, not numerically equal to its specific luminous radiation in lumens per square centimeter.

Defining equations :

$$L = \frac{dF}{dS},$$

or, when uniform,

$$L = \frac{F}{S}.$$

17. Coefficient of reflection—the ratio of the total luminous flux reflected by a surface to the total luminous flux incident upon it. It is a simple numeric. The reflection from a surface may be regular, diffuse, or mixed. In perfect regular reflection, all of the flux is reflected from the surface at an angle of reflection equal to the angle of incidence. In perfect diffuse reflection the flux is reflected from the surface in all directions in accordance with Lambert's cosine law. In most practical cases there is a superposition of regular and diffuse reflection.

18. Coefficient of regular reflection is the ratio of the luminous flux reflected regularly to the total incident flux.

19. Coefficient of diffuse reflection is the ratio of the luminous flux reflected diffusely to the total incident flux.

Defining equation :

Let m be the coefficient of reflection (regular or diffuse).

Then, for any given portion of the surface,

$$m = \frac{E'}{E}.$$

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* In practice, the brightness b of a luminous surface or element thereof is observed and not the normal brightness b_0. For surfaces for which the cosine law of emission holds, the quantities b and b_0 are equal.

20. Lamp—a generic term for an artificial source of light.

21. Primary luminous standard—a recognised standard luminous source reproducible from specifications.

22. Representative luminous standard—a standard of luminous intensity adopted as the authoritative custodian of the accepted value of the unit.

23. Reference standard—a standard calibrated in terms of the unit from either a primary or representative standard and used for the calibration of working standards.

24. Working standard—any standardised luminous source for daily use in photometry.

25. Comparison lamp—a lamp of constant but not necessarily known candlepower against which a working standard and test lamps are successively compared in a photometer.

26. Test lamp, in a photometer—a lamp to be tested.

27. Performance curve—a curve representing the behaviour of a lamp in any particular (candlepower, consumption, &c.) at different periods during its life.

28. Characteristic curve—a curve expressing a relation between two variable properties of a luminous source, as candlepower and volts, candlepower and rate of fuel consumption, &c.

29. Horizontal distribution curve—a polar curve representing the luminous intensity of a lamp, or lighting unit, in a plane perpendicular to the axis of the unit, and with the unit at the origin.

30. Vertical distribution curve—a polar curve representing the luminous intensity of a lamp, or lighting unit, in a plane passing through the axis of the unit and with the unit at the origin. Unless otherwise specified, a vertical distribution curve is assumed to be an average vertical distribution curve, such as may in many cases be obtained by rotating the unit about its axis, and measuring the average intensities at the different elevations. It is recommended that in vertical distribution curves, angles of elevation shall be counted positively from the nadir as zero, to the zenith as 180°. In the case of incandescent lamps, it is assumed that the vertical distribution curve is taken with the tip downward.

31. Mean horizontal candlepower of a lamp—the average candlepower on the horizontal plane passing through the luminous centre of the lamp.

It is here assumed that the lamp (or other light source) is mounted in the usual manner, or, as in the case of an incandescent lamp, with its axis of symmetry vertical.

32. Mean spherical candlepower of a lamp—the average candlepower of a lamp in all directions in space. It is equal to the total luminous flux of the lamp in lumens divided by 4π.

33. Mean hemispherical candlepower of a lamp (upper or lower)—the average candlepower of a lamp in the hemisphere considered. It is equal to the total luminous flux emitted by the lamp in that hemisphere divided by 2π.

34. Mean zonal candlepower of a lamp—the average candlepower of a lamp over the given zone. It is equal to the total luminous flux emitted by the lamp in that zone divided by the solid angle of the zone.

35. Spherical reduction factor of a lamp—the ratio of the mean spherical to the mean horizontal candlepower of the lamp.*

36. Photometric tests in which the results are stated in candlepower should be made at such a distance from the source of light that the latter may be regarded as practically a point. Where tests are made in the measurement of lamps with reflectors, or other accessories at distances such that the inverse square law does not apply, the results should always be given as "apparent candlepower" at the distance employed, which distance should always be specifically stated.

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* In the case of a uniform point-source, this factor would be unity, and for a straight cylindrical filament obeying the cosine law it would be $\pi/4$.

The output of all illuminants should be expressed in lumens.

37. Illuminants should be rated upon a lumen basis instead of a candlepower basis.

38. The specific output of electric lamps should be stated in terms of lumens per watt and the specific output of illuminants depending upon combustion should be stated in lumens per British thermal unit per hour. The use of the term "efficiency" in this connection should be discouraged.

When auxiliary devices are necessarily employed in circuit with a lamp, the input should be taken to include both that in the lamp and that in the auxiliary devices. For example, the watts lost in the ballast resistance of an arc lamp are properly chargeable to the lamp.

39. The specific consumption of an electric lamp is its watt consumption per lumen. "Watts per candle" is a term used commercially in connection with electric incandescent lamps, and denotes watts per mean horizontal candle.

40. Life tests—Electric incandescent lamps of a given type may be assumed to operate under comparable conditions only when their lumens per watt consumed are the same. Life test results, in order to be compared must be either conducted under, or reduced to, comparable conditions of operation.

41. In comparing different luminous sources, not only should their candlepower be compared, but also their relative form, brightness, distribution of illumination and character of light.

42. Lamp accessories.—A **reflector** is an appliance the chief use of which is to redirect the luminous flux of a lamp in a desired direction or directions.

43. A **shade** is an appliance the chief use of which is to diminish or to interrupt the flux of a lamp in certain directions where such flux is not desirable. The function of a shade is commonly combined with that of a reflector.

44. A **globe** is an enclosing appliance of clear or diffusing material the chief use of which is either to protect the lamp or to diffuse its light.

Photometric quantity.	Name of unit.	Symbols and defining equations.	Abbreviation for name of unit.
1. Luminous flux	Lumen	$F. \Psi$	1
2. Luminous intensity	Candle	$I=\frac{dF}{d\omega},\ \Gamma=\frac{d\Psi}{d\omega}$	cp.
3. Illumination	Phot, foot-candle, lux	$E=\frac{dF}{dS}=\frac{I}{r^2}\cos\theta.\beta$	ph. fc.
4. Exposure	Phot-second Micro phot-second	Et	phs. μphs.
5. Brightness	Apparent candle per sq. cm. Apparent candle per sq. in.	$b=\frac{dI}{dS\cos\theta}$	—
	Lambert	$L=\frac{dF}{dS}$	—
6. Normal brightness	Candles per sq. cm. Candles per sq. in.	$b_0=\frac{dI}{dS}$	—
7. Specific luminous radiation	Lumens per sq. cm. Lumens per sq. in.	$E'=\pi b_0,\ \beta'$	—
8. Coefficient of reflection	—	$m=\frac{E}{E}$	—

45. Photometric Units and Abbreviations

9. Mean spherical candlepower scp.
10. Mean lower hemispherical candlepower lcp.
11. Mean upper hemispherical candlepower ucp.
12. Mean zonal candlepower zcp.
13. Mean horizontal candlepower mhcp.
14. 1 lumen is emitted by 0·07958 spherical candlepower.
15. 1 spherical candlepower emits 12·57 lumens.
16. 1 lux=1 lumen incident per square meter=0·0001 phot=0·1 milliphot.
17. 1 phot=1 lumen incident per square centimeter=10,000 lux=1,000 milliphots=1,000,000 microphots.
18. 1 milliphot=0·001 phot=0·929 foot-candle.
19. 1 foot-candle=1 lumen incident per square foot=1·076 milliphots=10·76 lux.
20. 1 lambert=1 lumen emitted per square centimeter of a perfectly diffusing surface.
21. 1 millilambert=0·001 lambert.
22. 1 lumen, emitted, per square foot*=1·076 millilamberts.
23. 1 millilambert=0·929 lumen, emitted, per square foot.*
24. 1 lambert=0·3183 candle per square centimeter=2·054 candles per square inch.
25. 1 candle per square centimeter=3·1416 lamberts.
26. 1 candle per square inch=0·4868 lambert=486·8 millilamberts.

46. Symbols.—In view of the fact that the symbols heretofore proposed by this committee conflict in some cases with symbols adopted for electric units by the International Electrotechnical Commission, it is proposed that where the possibility of any confusion exists in the use of electrical and photometrical symbols, an alternative system of symbols for photometrical quantities should be employed. These should be derived exclusively from the Greek alphabet, for instance :—

Luminous intensity	Γ.
Luminous flux	Ψ.
Illumination	β.

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* Perfect diffusion assumed.

JUVENILE EMPLOYMENT.

Attention has recently been drawn to the admirable researches carried out under the supervision of the Committee on the Health of Munition Workers on the relations between hours of work and fatigue.

In a recently issued Bulletin (No. 13) the conditions of juvenile labour in factories is discussed. It is pointed out that many factors that have a depressing effect on workers generally have a specially bad effect on children. Expressions of opinion of factory inspectors are quoted to the effect that in many workshops children are being seriously overworked. Continued long hours give rise to a condition of general lassitude, dullness, and weariness that must have a prejudicial effect alike on the work and the health of the children. It is strongly advised that in no case should boys under 16 work for more than 60 hours a week. Eight hours of sleep are the minimum.

The seriousness of the matter lies in the fact that overworking of children appears to be so widespread. If one had only to deal with a few isolated cases, the result of temporary pressure, one might hope that a little perseverance on the part of inspectors would put things right. But the large number of instances commented on in the Report suggests that many employers in the country do not yet realise that these excessive hours are uneconomical and inhuman.

Equally important is the general care of children to whom the general supervision and guidance of older people is often essential. Facilities for recreation can do much to prevent staleness and fatigue. An interesting account is given of the work of Boy Visitors, who appear to be doing a most valuable work in supervising the well-being of juvenile workers and remedying conditions that may lead to permanent deterioration in physique.

The Committee is doing a national service in drawing public attention to this matter, and we hope they will persevere in their much-needed educational campaign.

MR. H. CORNISH	MR. J. SYKES	PROF. J. W. COBB	MR. P. N. HASLUCK	MR. M. E. SADLER	MR. L. GASTER	MR. A. J. MUNDELLA	MR. SYDNEY WALTON
(Cons. Secretary of the Institute of Journalists.)	*(Past-President of the Institute of Journalists.)*	*(Dept. of Coal Gas and Fuel Industries, Leeds University.)*	*(Hon. Treas. and Sec. of the Circle.)*	*(Vice-Chancellor of Leeds University.)*	*(Chairman of the Circle.)*	*(Chairman of the Lond. District, Institute of Journalists.)*	*(Welfare Dept., Ministry of Munitions.)*

Photograph taken outside the Hotel Metropole, Leeds, following the gathering of the Leeds Luncheon Club, on the occasion of the Visit of the Circle of Scientific, Technical, and Trade Journalists, Oct. 9th, 1916.

A VISIT TO THE UNIVERSITIES OF LEEDS AND SHEFFIELD.

(An account of a visit to the Universities of Leeds and Sheffield, and to various factories in these cities by the Circle of Scientific, Technical and Trade. Journalists, Oct. 8th—10th, 1916.)

In recent issues of this journal reports have been published of discussions at several meetings of the Circle of Scientific, Technical, and Trade Journalists, on the subject of Technical Education and Industrial Research. Following these discussions an invitation was given to members of the Circle and friends to visit the Imperial College of Science on May 31st, the object of this visit being to promote closer relations between the Universities and the scientific and technical Press, and to assist the latter in bringing about a fuller public appreciation of the benefits of technical education and industrial research.

The precedent of the Imperial College of Science has now been followed by the Universities of Leeds and Sheffield, who invited the circle of Scientific, Technical, and Trade Journalists, as the section of the Institute of Journalists chiefly interested in these matters, to visit these two cities on October 8th—10th. Throughout their stay the visitors were the guests of the Universities, and besides hearing something of their work, were afforded opportunities of seeing some of the factories most closely associated with their educational programme.

The party consisted of :—

Mr. F. Bourne Newton ‡ (*Caterer*), Mr. H. Cornish* (Cons. Sec. of the Inst. of Journalists (*School Government Chronicle*), Mr. A. T. Dale ‡ (*Plumber and Decorator*), Mr. E. Davis† (*Chemical Trade Review and Chemical Engineer*, &c.), Mr. J. S. Dow,‡ Mr. E. L. Dodd† (*Canadian Machinery and Manufacturing News*, &c.), Mr. L. Gaster*‡ (Chairman of the Circle of Scientific Tech. and Trade Journalists, *Illuminating Engineer*), Mr. Gilbert Wood*‡ (Vice-President of the Inst. of Journalists and ex-Chairman of the London District, *Architect and Contract Reporter*), Mr. J. L. Greaves † (*Stationery World*, &c.), Mr. Hartley Aspden,* Mr. P. N. Hasluck*‡ (Treasurer of the Circle of Scientific, Tech. and Trade Journalists), Mr. A. S. Jennings‡ (*Decorator*), Mr. F. Marshall† (*Power User*, &c.), Mr. A. J. Mundella* (Chairman of the London District of the Inst. of Journalists), Mr. H. E. Philpott (*Illustrated Carpenter and Builder*), Mr. S. C. Phillips† (*Paper Maker*, &c.), Mr. S. Rentell (*Electricity*), Mr. M. Ross (*Times Engineering Supplement*), Mr. Chambers Smith (*Municipal Engineering and the Sanitary Record*), Mr. G. Springfield* (Mem. Executive Committee of the Inst. of Journalists), Mr. J. Sykes* (Past-President of the Inst. of Journalists), Mr. W. A. Standring† (*Motor Cycle*, &c.), Dr. S. A. Vasey (*Lancet*), and Mr. Sydney Walton (Ministry of Munitions, Welfare Dept.).

Mr. Gilbert Wood, Mr. G. Springfield, and Mr. M. Ross were unable to be present at Leeds and joined the party at Sheffield. Dr. R. A. Gregory (*Nature*) and Mr. Pendred (*Engineer*), while expressing their interest in the visit, were prevented by editorial duties from being present. Mr. E. J. P. Benn (*Hardware Trade Journal*, &c.), Mr. H. Val Fisher (*Advertising World*), Mr. F. Hinde (Chairman of the Executive Committee of the Inst. of Journalists), Mr. Harold Jeans (*Iron and Coal Trades Review*), Mr. T. C. Elder (*Engineering Review*), and Mr. A. J. Meyjes (*Ironmonger*) sent messages of regret at being unable, at the last moment, to join the party, owing to pressure of work.

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* Fellow of the Institute of Journalists.

† Representing the British Association of Trade and Technical Journalists.

‡ Member of the Committee of Scientific, Technical, and Trade Journalists.

Among others, the following journals made arrangements to be represented either by members of the party or through local representatives:—*Nature*, *The Engineer*, *The Electrician*, *The Journal of Gas Lighting*, and *The Gas World*, &c.

The party arrived at Leeds on the night of October 8th, and were received at the Queen's Hotel by Mr. M. E. Sadler, Vice-Chancellor of the University of Leeds. A number of local journalists were present at the reception and joined in welcoming the visitors, among those who spoke being Mr. Phillips (*Yorkshire Post*), Mr J. Sykes (Fellow and Past-President of the Inst. of Journalists), Mr. Kenyon (*Yorkshire Observer*), Mr. Raynes (*Leeds Weekly Citizen*), Mr. Outhwaite (*Leeds Mercury*), and Mr. Edge (*Yorkshire Herald*). Mr. L. Gaster (Fellow Inst. Jour., Chairman of the Circle) replied for the visitors.

Visit to Leeds University.

On the following morning the party made their way to the University, where they were again joined by some of the local journalists. They were received in the Great Hall by Mr. Sadler, who delivered a most interesting and inspiring address, of which the following is a summary:—

Address by Mr. M. E. Sadler, Vice-Chancellor of Leeds University.

It is incumbent upon all Universities to endeavour to be of service to industry. Old and new they face this obligation. The ever-increasing importance of industry in modern life makes it incumbent upon Universities to give a suitable training to those who intend to follow an industrial career. The applications of science to industrial operations make it natural and inevitable that there should be intimate connection between industrial needs and the University Laboratories. And the importance of emphasising its human side in all industrial undertakings brings about a close relation between the factory and parts of its University courses (training in the humanities) which to a superficial view might seem remote.

The modern Universities, set in industrial districts and drawing their undergraduates in great measure from families which are concerned in industrial enterprise, were naturally quick to feel the new obligation. At Leeds, we have been greatly helped by the counsels of the Advisory Committees, attached to each of our technological and to some of our professional departments. In the study of the Textile Industries, and of Colour Chemistry and Dyeing, for example, in the departments which the University owes to the munificence and foresight of the Clothworkers' Company, the Advisory Committee, representative of the business experience of the Textile Trades, gives us practical guidance. The same is true of the Advisory Committees attached severally to the Department of Coal Gas and Fuel Industries (in which the University has received most valuable assistance and support from the Institution of Gas Engineers), to the Mining Department (in connection with which indispensable help has been given by the Drapers' Company and by the West Yorkshire Coal Owners' Association), to the Department of the Leather Industries (which is indebted to the constant aid and advice of the Leather Industries Federation), to the Department of Agriculture (which is advised by the Yorkshire Council for Agricultural Education), and to the Civil, Mechanical, and Electrical Engineering Departments. These Advisory Committees report to the University Council, which is the executive body of the University. Their members give their services voluntarily. Through them the University is kept in close touch with the practical and scientific experience of the various branches of industry. On each Committee, in order that there may be interchange of view and harmony of action, the academic element is sufficiently represented. The University Court, the supreme authority, is fully representative of business as well as of academic experience. The aim is to secure at every point a fusion between different types of knowledge and a co-ordination of effort in the furtherance of education and of scientific research.

Thus representative of the different elements in the modern social structure, the University is by Charter autonomous. Its income—about £70,000 a year—falls into three parts. One-third comes from endowments and fees; a third (a large third) from Government grants received from the Treasury, the Board of Education, and the Board of Agriculture; and a third (a small third) from grants from the County Councils of Yorkshire, in West, East, and North Ridings, and from the County Boroughs of Leeds and Wakefield. Stability, progress, and a sense of responsibility on the part of the University Authorities (including its Advisory Committees) are enhanced by this balance of financial support. The University is, and should be, in very intimate touch with the Government; but it would be undesirable for the State Departments to be the sole source from which the University funds are drawn. Such an arrangement would put too much control in the hands of distant bodies of officials who, though animated by a high spirit of public service, are somewhat remote from the ever-developing needs of industry and not omniscient about the requirements of education and research. Similarly the connection between the University and the Local Authorities is very intimate. They act in close co-operation, for the good of the districts which they serve. By personal interview, letter, and telephone they are in constant communication. The work of both is carefully related. But it would be inexpedient if the policy of the University were framed in the absolute control of the Local Authorities which, well-informed of many local needs, are not necessarily in a position to judge what should be done by the University in the National and Imperial interest.

The effectiveness of the work of the University depends in the last resort (granted adequate equipment and resources) upon the spirit of its personnel. This is the vital thing. It must be inspired by a disinterested zeal for knowledge, for truth, and for service. It must combine deference to outside experience with a sturdy independence of judgment, courage, and tact; the concentrated passion for research with the unselfishness of the teacher; intellectual ardour with practical good sense. And it is found where all branches of the University's work are in some degree interdependent. The need for strengthening the human side in all individual effort makes the humanistic side of the University studies increasingly valuable to the scientific and to the technological. The reality of the scientific and technological studies helps the humanities in focussing its work upon definite aims conducive to the welfare of the community which it endeavours to serve.

The visitors were then conducted over the building by the professors of the various departments, many of which are unique. To technical journalists the varied character of several of the more technical departments, which are closely related to the industries of Yorkshire, was specially interesting. The School of Chemistry and Applied Chemistry is very widely known; the School of Agriculture is stated to be the largest but one in the United Kingdom, and the Departments of Colour Chemistry and Textile Industries are regarded as the best in Western Europe. All courses are open equally to men and women.

Department of Organic Chemistry.

The first department visited was that dealing with Organic Chemistry, where the party were received by Professor J. B. Cohen, B.Sc., Ph.D., F.R.S. This department has done useful service in connection with the war, especially in the production of many drugs hitherto imported from abroad. Since the outbreak of war a variety of compounds needed by the medical profession have been prepared and sent out from the University, including the chloramines, a cheap and effective hypochlorite antiseptic, and novocaine and eucaine, now largely employed as local anæsthetics.

Leather Department.

Passing on to the Leather Department, the visitors were met by Professor Procter, D.Sc., F.I.C., who explained some of the interesting processes developed in the

University Laboratories. In the ordinary course many investigations of value to the trade are carried on; there is plant for manufacture, on a small scale, of all kinds of leathers; a museum with an extensive collection of raw materials and products of leather manufacture; and a laboratory in which students are trained in the chemical methods employed in the control of processes and the detection of faults. In the bacteriological laboratory culture-media required by the hospitals for the isolation and detection of disease germs are being prepared, and a series of special investigations are being conducted for the War Office. One object of great interest to the visitors was a machine by which the superficial area of any piece of leather can be measured in a few seconds, and we understand that this has proved very useful for checking deliveries. Visitors were also shown the research laboratory erected by the leather industries of the world in recognition of Professor Procter's services to the leather trade, where investigations are being conducted on colloids, a class which includes almost all the raw materials of leather manufacture, and has important chemical and physiological applications.

Department of Textile Industries.

The party were then shown over the Department of Textile Industries by Professor A. F. Barker, M.Sc.; all were much impressed by the excellent equipment and organisation of this section of the University. During the past year important researches have been undertaken on the fabrics for airships and aeroplanes, and the clothing supplied to troops at the Front. These included a series of tests on the comparative cost and efficiency of British and German Army cloths—a comparison which, we were informed, fully justified the view that the British material is superior and less costly. Experiments are also in progress on the electrification of textile fibres, carbonising and finishing, the preparation of colour dyestuffs for colour sensitisation. An investigation into the growth and treatment of flax is being carried out by the University at Selby, and is closely associated with the Textile, Agricultural, and other Departments.

Colour Chemistry and Dyeing.

In the Department of Colour Chemistry and Dyeing, Professor A. G. Perkin, F.R.S., F.I.C., described some of the important work carried on in relation to the production of dyes, of which this country has been in sore need since war broke out. British Dyes, Ltd., have secured a laboratory in the University for the use of certain of their research chemists, under the supervision of the Professor of the department—a form of co-operation between University and factory which cannot but be beneficial. Visitors were shown a great variety of colour-materials entirely prepared in this country. Improvements have also been effected in the manufacture of T.N.T. and picric acid.

Department of Coal Gas and Fuel Industries.

In another department (Coal Gas and Fuel Industries) the testing of coal gas by-products, such as toluene, required for explosive works is systematically undertaken. This department has also undertaken for the Government the sampling and testing of high explosives manufactured in the district, and this work was in progress on the occasion of the visit. It is of interest to recall that the Livesey Professorship, held by the head of this department, was initiated as a memorial to Sir George Livesey, and the department is in connection with an Advisory Committee, the members of which are nominated jointly by the Institution of Gas Engineers, the Society of British Gas Industries, and the University. Apparatus is provided for high temperature measurements, the compression and liquefaction of gases, furnace work with high and low pressure gas and air, &c.

The visitors were next entertained at the Hotel Metropole as guests of the Leeds Luncheon Club, when an address was given by Mr. H. A. L. Fisher, M.A., LL.D., Vice-Chancellor of Sheffield University, on "India and the Empire." Mr. A. J. Mundella (Fellow of the Inst. of Journalists and Chairman of the London District of the Institute) spoke on behalf of the visitors.

Visits to Factories.

The afternoon was devoted to visits to the Leeds Army Clothing Depot, to the factory of Messrs. L. Albrecht and Albrecht, a large wholesale clothing factory, now engaged on the manufacture of Army garments and cartridge bags, and the Cardigan Boot Factory, at present mainly occupied with orders for the Russian and Italian armies. These factories were selected in view of the close relation between the processes of manufacture and the work of the University, and many of the processes seen were of great interest.

At five o'clock the party were entertained to tea by the Lord Mayor (Mr. Chas. Lupton), who gave a short address of welcome, in the course of which he traced the development of some of the most important industries of the city. Mr. F. Bourne Newton replied on behalf of the visitors, who afterwards left for Sheffield by the Midland train.

The Visit to Sheffield.

On arrival at the Grand Hotel, Sheffield, the party were met by Mr. H. A. L. Fisher (Vice-Chancellor of the University of Sheffield), and by Professor Ripper, Dean of the Applied Science Department, who presided at the evening meal. The local Press was again represented, and several Sheffield journalists joined the party in their visit to the University next day.

The visitors were received at the University Buildings (Western Bank) by the Vice-Chancellor and several members of the staff. The following is a summary of the Vice-Chancellor's address :—

Address by Mr. H. A. L. Fisher, Vice-Chancellor of the University of Sheffield.

I think it may be of some interest to you if I give you a short sketch of the work of the University.

The Sheffield University is the youngest of all the British Universities. It is 11 years old. But although it is the youngest of the Universities, it started from organisations which existed previously. It was formed really out of the amalgamation of three educational institutions, the Firth College, for Arts and Pure Science, founded 1879, the City Technical School, founded 1886, which has become the Applied Science Department of the University (and which you are subsequently to visit), and the Medical School. It was by the amalgamation of these three institutions that the University College of Sheffield was first formed ; and the University College subsequently developed into the University of Sheffield. And the fact of its historical origin is still seen. We have here two great blocks of buildings, the block in which you are seated at present, the Department of Pure Science and Arts, at Western Bank, and when we have seen the laboratories here we shall proceed down to St. George's Square, where you will visit the Department of Applied Science.

Now you have in your hands a memorandum compiled by Dr. Wynne, the Dean of our Faculty of Pure Science, which will give you some idea of the work done in our departments of Pure Science in the University. Of course, like all other Universities, we have been very greatly affected by the war. Primarily, of course, it has meant the depletion of our male students. Then again, it has meant the carrying out of a large number of operations which otherwise it would not have occurred to us to carry out. I think that every one, almost every one, of the departments of the University, has in one way or another been affected by the war. The Chemical Department has been very busy making anæsthetics required by the Army ; the Metallurgical Department has been doing confidential work for the Admiralty.

We have been training munition workers from quite early in the course of the war, for it became clear that it was desirable to increase the number of such workers. More than 1,000 persons have been trained in the use of the lathe for the purpose of the armament works at Sheffield.

Then again, we have established in the University a very successful Hospital Supply Depot, not only for the making of bandages of all kinds for the hospitals, but also for the making of crutches and surgical instruments, and this Hospital Supply Depot has been supplying hospitals in England, in France, in Salonika, and at Alexandria, and has proved to be of the utmost value.

You will visit very shortly our Medical Department. And I am going to put into your hands a memorandum drawn up by Dr. Leathes, our Professor of Physiology, and a most eminent physiologist, which will give you some idea of the place and the prospects of the medical school in Sheffield. The medical school is at present a very young school. It is, I think you will agree, admirably fitted up, so far as its laboratories are concerned, and I foresee a very great future for the medical school in this University, not only by reason of the excellence of the equipment we have been able to provide, but also by reason of the fact that we have in the Sheffield Hospitals a mass of clinical material available. The Sheffield industries produce peculiar types of dust disease which are well worth the investigation of men of science. And we have this great advantage, at any rate, to start with, that owing to the fact that the school is at present somewhat short of pupils, the students are able to receive more individual attention here than is the case in the crowded schools of London or Edinburgh. Further, the school is admirably adapted for the training of women students who have here just the same privileges as the men.

Now I need hardly point out to you, gentlemen, who know so much about the scientific and technical study of the work of the Universities, how important the science of chemistry is for the industries of Sheffield. It is the basis of the steel industry. And I think it is significant of the close connection which exists between the industry and the University that only the other day I had an application from one of the greatest of Sheffield steel firms, asking us whether we could not provide a compendious course in inorganic chemistry which would enable the chemical laboratories of our great city industries to receive an almost immediate supply of female labour sufficiently trained to carry on the work of the laboratories. We have, of course, responded to that appeal, and these courses will be instituted.

Then again, we have established, since the war began, a Scientific Advisory Committee in the University — a Scientific Advisory Committee for the purpose of solving problems submitted to us by manufacturers of Sheffield and its neighbourhood, and a very large number of cases have come before our Scientific Advisory Committee, and have been dealt with in a satisfactory manner.

It is sometimes thought that the war has necessarily suspended University development. It has done so in some directions in this University, but we have embarked upon a scheme during the war which is going to be of very great value to the country. We have established an Institute of Glass Technology. Now, gentlemen, you probably know that South Yorkshire is the seat of a very great part of our national glass industry. It is true that it is chiefly the glass bottle industry, but you will all be aware that Sheffield is also the home of the silver trade, and that silver and glass are natural allies. And it seemed to us, therefore, that the time has come for the University to take up the question of glass technology, because, gentlemen, it is a very striking fact that until the war there was no scientific teaching of glass technology in any one of our technical institutions in this country. Consequently the University took the matter up, and in view of the strength of the existing equipment in metallurgical and engineering, each of which is a science auxiliary, with every prospect of success. It has received promise of support from the Yorkshire Glass Association. We have promises of support also from the Advisory Committee of the Privy Council. We have purchased a site and we are in the course of erecting buildings, and we hope that before Christmas the new Glass Institute will have been erected, and that it will be undertaking important optical problems for the Ministry of Munitions. We are in close touch with the Ministry of Munitions, and we have therefore their full support and encouragement—in fact, they have communicated to us a considerable number of urgent optical problems which they desire us to take in hand.

But we have progressed in other directions. We have founded a Lectureship in Russian. And in view not only of the existing connection between the great Sheffield armament firms in Russia, but in view also of the prospective developments of British industry in Russia, it is obviously of the greatest importance that the knowledge of Russian should be diffused in this country. Our Russian Lecturer is already at work, and a very considerable number of pupils have come forward in order to learn the language.

At the beginning of this war it was, as you are aware, a very important function of every University to attempt to enlighten the public as to the true causes of the war and as to the necessity for a great national effort, and accordingly in this University a War Lectures Committee was established in order to carry out patriotic propaganda and educational propaganda in Sheffield and its neighbourhood. A large number of lectures were delivered in Sheffield by eminent specialists, who were invited down to the University. And not only were these formal addresses given but a considerable number of short addresses, partly of an educational character and partly of a recruiting character, were given in the town of Sheffield and in the villages around Sheffield, and in the dinner-hour at the great Sheffield works. And I believe that propaganda had a very powerful effect in directing public opinion in Sheffield and its neighbourhood in the right course.

Now, gentlemen, I think perhaps we had better proceed to the inspection of some of our laboratories. I ought perhaps to say that you will observe a good number of class-rooms, at present occupied by somewhat juvenile persons, who are not members of the University, but who are members of the City Training College, an institution to whom we have extended our hospitality, owing to the fact that their buildings have been taken over for the medical purposes of the Army.

Subsequently a few remarks were made by Ald. A. J. Hobson, the Treasurer of the University, who stated his conviction of the great value of the work done at the University in encouraging the applications of science to industry, which fully justified the previous expenditure incurred. He believed that the Press could exert a great and valuable influence in bringing the importance of this matter home to the nation.

Chemical and Medical Departments.

The visitors then passed through the Chemical and Medical Departments under the guidance of the Dean of the Pure Science Department, Dr. Wynne. One excellent feature of these lecture-rooms and laboratories is the ample provision of daylight and the scrupulously clean and orderly arrangements. The laboratories are exceptionally well-equipped for microscopic and photographic work, and the department is also fortunate in having the nucleus of a well-stocked museum.

At the conclusion of this part of the visit a few words were said by Mr. Leon Gaster, who pointed out that part of the work carried on in this department appeared to be closely related to that undertaken at the Institute for the study of Industrial Diseases, under the supervision of Dr. I. Devoto, of Milan, which he understood was the first institution of this kind to be organised exclusively for such researches. The Institute was supported by the insurance companies, and the money expended on the study of such diseases and their prevention had been most profitably employed. Mr. Gaster also referred to the important step taken by the University in establishing a Department for the Study of Glass Technology, and expressed the hope that it would include in its sphere of action the study of illuminating glassware.

Engineering and Metallurgical Department.

The party then passed to the Engineering and Metallurgical Departments. Here they were addressed by Dr. Ripper, who gave some instances of the very valuable special researches undertaken for various Government Departments in connection with the war. The buildings at St. George's Square form the headquarters of the Sheffield Munitions of War Committee, and the technical resources of the department have been utilised on a large scale by the Authorities. In addition, advice has been given by the University on many points that have arisen since the outbreak of war in connection with various steel industrial operations, such as the hardening and tinning of steel, polishing of razors, contact production of sulphuric acid, torsion testing, etc., while the Department of Geology has been engaged in searching for a substitute for the Belgian sand used in glass manufacture.

The visitors were conducted over several of the laboratories where interesting testing and metallurgical work is in operation. While steel and iron work forms the chief item, all the chief industrial operations in connection therewith being reproduced on a small scale, a non-ferrous department has recently been added, and has already done good service in experiments on the production of cupro-nickel, required in munition work. The department has specialised steel microphotography. It is stated that of 32 recent contributions to the micrography of steel, 29 emanated from the laboratory of the University.

Visit to Factories.

After leaving the University a visit was next paid to the Atlas Works of Messrs. John Brown and Co. Although it was naturally only possible to pass rapidly through a small section of the works, the visitors were much impressed by the vastness of the operations carried on, and the large area covered. A short time was spent in the research laboratory, where an account of the work undertaken was given by Dr. Hatfield, and the party were then entertained to luncheon by the Directors. It had been anticipated that the Master Cutler (Mr. W. H. Ellis) would preside, but in his unavoidable absence in London the chair was taken by Mr. A. Willis Dixon, the General Works Manager and Director. Among others who were present were the Vice-Chancellor, Dr. Ripper, and Alderman A. J. Hobson.

Mr. Dixon read some remarks that Mr. Ellis had prepared on the subject of the Sheffield Steel Industry. Some people, he said, were too apt to assume that Germany was more diligent in applying scientific methods to steel making than we had been. In some things this might be so, but, speaking generally, the importance of scientific method was fully appreciated by the great steel firms in Sheffield; their managers were trained men, and they were constantly carrying out experiments and endeavouring to make improvements. Mr. Dixon added that Sheffield was the cradle of the steel industry. Of the 28 great discoveries made in the steel world, 24 had come from within the British Empire, while Germany could claim but one. Finally, Mr. Dixon remarked that the firm were also strong believers in hygienic and satisfactory working conditions; cleanness spelled efficiency, and lofty, well-ventilated and well-lighted shops meant that the working man could give a better return for his wages. On this point working men and employers were in full accord.

Mr. Gilbert Wood (Fellow Inst. Jour. and Vice-President of the Inst. of Journalists), and Mr. L. Gaster (Fellow Inst. Journ. and Chairman of the Circle), expressed the thanks of the visitors, who were afterwards taken over a part of the shell factory of Messrs. Thos. Firth and Sons. Here again operations on a tremendous scale were witnessed, shells of every kind, both for naval and land work, being poured out in an endless stream from long rows of shops (many of them, it was remarked, standing on what were green fields only a few months ago). A feature of these works was the employment of women operators, many of whom were undertaking, in a most workmanlike manner, tasks which before the war would invariably have been assigned to men.

The party left Sheffield by the night train for London, much impressed by the very active part taken by the Universities in the life of Leeds and Sheffield, and their intimate relations with the industries of these thriving cities. Here, at all events, the application of science to industry is being seriously considered and the preparations that are now being made should bear good fruit in the future.

Reference should also be made to the co-operation of the local Press in both cities, which, by the presence of its representatives, not only accorded its welcome to the visitors but signified its appreciation of the excellent work which the Universities of Leeds and Sheffield are now doing.

GAS AUTHORITIES AS SUPPLIERS OF ELECTRICITY.

An interesting paper on the above subject was read by Mr. J. W. Napier at the annual meeting of the North British Association of Gas Managers in Edinburgh last September.

Mr. Napier, after mentioning cases in which gas companies had been granted Parliamentary powers to supply electricity (such as the Tottenham District Light, Heat and Power Co.), described the conditions prevailing in Alloa, where both gas and electricity are supplied by the Corporation.

In the past, owing to various unsatisfactory conditions, the supply of electricity did not prove remunerative, the deficit in this section being met out of the profits from gas ; this was chiefly due to the small supply of electricity for power, and in 1910—1914 much larger plant was installed, in the form of electric generators driven by direct coupled gas engines supplied from a producer gas plant. The system, representing an arrangement satisfactory alike to the gas and electrical departments, has proved very satisfactory in practice, and, from the standpoint of coal-saving, is regarded as of national importance. A scheme for a producer gas plant of the Mond type, with recovery plant, has been now decided upon. This will supply gas to both stations—to the gas works for heating retorts, and to the electricity supply station for driving the gas engines. The production of ammonia as a by-product should thus be carried on under efficient conditions.

For many years Alloa has enjoyed an exceptionally low rate for gas (in pre-war times 2s. 1d. to 2s. 4d. for lighting, and 1s. 4d. to 1s. 10d. for power), and the consumption has steadily risen to 150,000,000 cubic feet.

A corresponding improvement in the electrical side of the business is now to be noted, the annual output having increased from 100,000 units in 1910 to 800,000 units in 1916. Mr. Napier states that there is no collision of interests in supplying both forms of energy. "Consumers demand whatever form of energy is most convenient and best suited to their requirements, and they are supplied accordingly. A showroom was recently opened in which there is exhibited lighting, heating, and cooking apparatus for both gas and electricity."

In Mr. Napier's opinion the view that encouraging the supply of electricity lessens the demand for gas is quite incorrect. The use of gas is far from having reached its limit in any city, and the addition of electrical business does not mean that this is abstracted from the gas department. On the contrary, the recognition that in certain cases electric lighting is most convenient or electric motors preferable to gas engines, enables business to be added that might not otherwise be secured, and, as the Corporation owns both supplies, there is no conflict of interests.

Mr. Napier concludes his paper as follows :—

"From the evidence now adduced it may be fairly claimed that the co-existence of gas and electricity supply under one control is at once a practical and commercial proposition. The fresh field of business will appeal chiefly in the case of towns where there is at present no electricity supply. It is my settled conviction that what is required of the gas industry of to-day is a broadening of the basis of its function as suppliers of the public need for energy—gas and electricity. There is small doubt but that gas companies, if they do not prepare the way, will be met in the near future with competition where there is no electricity supply at present. It is a true indication of strength and vitality when an industrial business can comprehend the issues that lie in front of it, and having done so, prepare accordingly."

A LIGHTING CODE IN PENNSYLVANIA.

In a recent issue of the *Lighting Journal* (U.S.A.), Mr. C. E. Clewell mentions that the Pennsylvania Department of Labour and Industry has adopted a Lighting Code for factories, mills, and other workplaces, to become operative on July 1st, 1916. The adoption of this code is of special interest as one of the first tangible results of the work of the American Illuminating Engineering Society in the United States, whose "Code," issued last year, is closely followed in that drafted by the Pennsylvania Industrial Board. This is stated to be the first occasion on which factory lighting regulations in the United States have been based on the intensity of illumination required for various classes of work. The minimum intensity for five distinct classes of work is given as follows :—

Foot-Candles on the Work.

	Minimum.	Ordinary Acceptable Practice.
1. Roadways and yard thoroughfares ..	0·05	0·05—0·25
2. Stairways, passage-ways, aisles, storage spaces, &c. ..	0·25	0·25—0·50
3. Rough manufacturing operations, such as foundry work, rough machining, rough assembling, rough bench work ..	1·25	1·25— 2·50
4. Fine manufacturing operations, such as fine lathe work, pattern and tool making, light coloured textiles, tobacco manufacture	3·50	3·50—6·00
5. Special cases of fine work, such as watch-making, engraving, drawing, work on dark coloured textiles	5·0	10·0—15·00

Other regulations require in general terms that (1) glare either from lamps or unduly bright surfaces, producing eye-strain, are to be avoided ; (2) exposed bare lamps shall not be used except when they are out of the ordinary line of vision, and lamps should be suitably fitted to minimise glare ; (3) lamps must also be so arranged as to secure good distribution of light on the work, avoiding objectionable shadows and sharp contrasts in intensity ; (4) emergency lighting shall be provided in all work space, gangways, stairways, passage-ways, and exits ; such lights shall be so arranged as to insure their reliable operation when, through accident or other cause, the regular lighting is extinguished ; (5) switching and controlling apparatus shall be so placed that at least pilot or night lights may be turned on from the main point of entrance.

In the course of the article an abstract of the chief recommendations of the Report issued by the Home Office Departmental Committee in this country is also given. The conclusions embodied in this Report are in good general agreement with the requirements now being framed in the United States, and it is evident that the movement towards better industrial illumination is making steady progress in both countries.

The *American Machinist*, in congratulating Pennsylvania on taking the initiative in making provisions for the adequate lighting of factories, remarks that in regulations of this kind where pioneering work is involved, the rulings must not be looked upon as final, but as representing what may be expected in the present state of illuminating engineering. No doubt they will require modification in course of time. Meantime it is of interest to ask," What State will be next?'

LIGHTING OF VEHICLES.

NEW ORDER UNDER THE DEFENCE OF THE REALM ACT.

AN Order under the Defence of the Realm Act (No. 713, 1916), relating to the lighting of vehicles in places outside the Metropolitan and City of London Police Districts, was issued on October 6th.

Part I. directs that every vehicle on any street, highway, or road to which the public have access must, between half-an-hour after sunset and half-an-hour before sunrise carry lamps as follows:—

(A) At the front, a lamp or lamps displaying to the front a white light. Except in the case of a bicycle or tricycle (other than a motor tricycle) one such lamp must be placed on the extreme off or right-hand side of the vehicle: if a second lamp is carried it must be placed in the corresponding position on the extreme near or left-hand side of the vehicle; and

(B) At the rear, a lamp displaying to the rear a red light. The lamp carried for this purpose on any vehicle other than a bicycle or tricycle must be placed on the off or right-hand side of the vehicle.

Hand carts and wheeled bicycles (near the edge of the roadway) need only carry a white light to the front and a red light to the rear.

On and after January 1st, 1917, two lamps displaying to the front a white light must be carried on all vehicles (except bicycles and tricycles).

Lamps must be properly trimmed, lighted, and attached so that the light from each lamp is visible in the prescribed direction for a reasonable distance without obstruction.

Part II. requires that headlights on tramcars must not be of a greater brightness than is necessary for the public safety, and the inside lights of tramcars and omnibuses must be reduced, shaded, or obscured so that no more light is used than is necessary to enable fares to be collected, and the light is prevented, so far as practicable, from being visible from outside.

The following specific restrictions relating to the headlights of vehicles and motor-cars are of special interest:—

1. The use of headlamps on motor cars is prohibited and not more than two lamps showing a light to the front may be used on any vehicle, except that headlamps not exceeding two in number may be used in addition to the sidelamps carried in compliance with Part I. of this Order, if the sidelamps burn only candle or oil and have not lens fronts. All such headlamps must comply with the later requirements of this Order.

2. In electric lamps the bulb must not exceed 12 watts, or give in use a greater candlepower than the 12-watt (12 nominal candlepower) bulb as standardised for sidelights by the Engineering Standards Committee (Report No. 69).

3. In acetylene lamps the burner must not consume more than 14 litres (½ cubic foot) per hour.

4. In oil lamps only one burner may be used: the wick must not exceed three-quarters of an inch in width.

5. In electric and acetylene lamps the diameter or longer side of the front glass, according as it is circular or rectangular, must not exceed 6 inches, or the front glass must be permanently obscured so that no light can pass except through a central portion which does not exceed 4½ inches in diameter.

6. The front glasses of (1) all electric and acetylene lamps, and (2) lamps burning candle or oil with lens fronts, must be obscured—

(A) In electric lamps, with at least one thickness of ordinary white tissue paper;

(B) In acetylene lamps and in candle and oil lamps to which this paragraph applies, with at least one thickness of ordinary white tissue paper or with paint, ground glass, or a disc of some other uncoloured material so that the obscuring effect produced is not less than that of one thickness of ordinary white tissue paper.

The paper, paint, or disc must cover the whole of the portion of the front glass through which light can pass and must not be wetted, oiled, varnished, or treated in any other way so as to increase its transparency.

Side panels of electric and acetylene lamps, except small red or green side panels, must be covered over with some completely opaque material. This paragraph shall not apply to the lamp displaying a red light carried at the rear of a vehicle.

In Part III. the following further restrictions on the use of lights on vehicles have effect in certain cities, boroughs, and districts (a list of which is given):—

1. Headlamps on motor cars must not be used, and all other lamps to which paragraph 6 of Part II. of this Order applies must be further obscured with a cap or disc* constructed and attached as follows:—

(A) The cap or disc must be made of completely opaque material, must fit near to the front glass of the lamp and must cover it so as to prevent the passage of light except through the apertures cut as provided in paragraph 1 (B) below.

(B) The apertures must be circular, half an inch in diameter; they must be six in number and spaced approximately evenly round the disc so that no portion of any of the apertures is nearer the centre of the disc than one-quarter the diameter of the effective front of the lamp, if it is circular, or one-quarter the longer side, if it is rectangular.

2. The reflectors of all other lamps burning candle or oil which are provided with a reflector and have a front glass exceeding 3 inches in diameter, must be covered with some non-reflecting material, in lieu of using the cap or disc described in paragraph 1.

It is to be noted that Parts II. and III. in this Order are not to apply to the lamps used on any fire brigade vehicle when such a vehicle is actually proceeding to a fire.

CATTLE DROVERS TO CARRY LIGHTS.

We notice that in a further Order, under the Defence of the Realm Act it is stated that on and after October 22nd, any persons driving or leading horses, cattle, sheep, &c., along public thoroughfares during the period between half-an-hour after sunset and half-an-hour before sunrise, must carry a lamp showing a white light to front and rear. Where there are not more than four animals the light is to be carried by the person leading them. If there are more than twenty head of cattle or more than one hundred sheep, goats, &c., a second lamp must be provided.

PROBABLE INCREASE IN PUBLIC LIGHTING IN EDINBURGH.

We understand that a series of experiments has been made in Edinburgh with a view to improving the public lighting, so as to comply with the requirements of the Authorities, and make better provision against possible dangers and accidents. The experiments are in the direction of using low candlepower lamps at frequent intervals, either 100 c.p. lamps on alternate lamps or 50 c.p. lamps on all of them. The latter arrangement which gives an illumination which, though weak as compared with that prevailing in pre-war days, is continuous from lamp to lamp, seems preferable. It is hoped that the Authorities will accept the view that this degree of increase can be granted with safety.

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* This cap or disc is illustrated in a sketch in the Second Schedule to this Order.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

EMERGENCY LIGHTING ON BOARD SHIP.

With reference to the article that appeared in our last issue on "Illumination in the Navy" (p. 281), our attention is drawn to the question of emergency lighting circuits.

We are informed that in view of the new requirements of the International Shipping Association a special Automatic Emergency Lighting Plant has been designed by Messrs. R. A. Lister and Co., Ltd. (known as the "S.O.S. Lister-Bruston"). The special features claimed for this plant are:—

(1) The automatic starting immediately the main ship's supply falls below a predetermined point.

(2) Automatic daily testing. The plant starting up at any predetermined time, and running for any period that may be desired, at the end of which it automatically stops.

(3) Should the plant be out of working order or the engine not be running up to its proper speed a red lamp lights up in any part of the vessel where it may be required; or an audible indication can be arranged.

(4) An automatic change-over-switch is fitted on the switchboard and any circuits may be connected to the emergency lighting system and automatically changed over from the main ship's supply when the automatic set starts up.

In addition there is the advantage claimed generally for all Lister-Bruston plant, that only a very small battery outfit is needed; this is an important consideration on board ship.

We are informed that Messrs. Pass and Seymour (of Syracuse, N.Y., U.S.A.) have made arrangements with **Messrs. The Benjamin Electric, Ltd.** (in Rosebery Avenue, London, E.C.), to represent them in the sale of P. & S. Handy Electrical Wiring Devices for England, Ireland, Scotland, and Wales.

Some of these special devices, including the Shurlock Socket, are described in an attractive booklet issued by Messrs. Pass and Seymour, of which full particulars can be had on application to Benjamin Electric, Ltd.

Imperial Light, Ltd., are issuing a leaflet descriptive of the "Imperial" Flare and Hand Lamps in various portable patterns. We understand that since the outbreak of war there has been an enormous demand for such portable acetylene lamps which, besides being useful for many industrial uses at home, have many military applications.

PUBLICATIONS RECEIVED.

Can you believe your eyes ? (address at the opening of the Course in Physiology in the University of Manchester) ; Health, Fatigue and Repose (Lady Priestly Memorial Lecture delivered in London, Nov. 27th, 1913) *; Curiosities and Defects of Sight (Lecture delivered before the British Association,* 1915).

THE above are a series of lectures delivered at various times by Dr. William Stirling, Professor of Physiology and Histology in the University of Manchester, and now reprinted in booklet form. Many of the curiosities of sight described are very interesting and are illustrated by some ingenious devices. Professor Stirling discusses the production of mental and muscular fatigue, and mentions several forms of apparatus (such as the "ergograph") by which it can be tested. In these days when conditions in factories are being so closely studied, the dissemination of such information in a popular and readable form is a useful service.

The Stability of Vulcanised Rubber and the Optimum Cure ; the Function of Litharge in the vulcanisation of Rubber by Henry P. Stevens (reprinted from the Journal of the Society of Chemical Industry).

PERSONAL.

We are informed that Lieut. A. R. Courtenay, until recently acting-manager of the Publicity Department of the General Electric Co., Ltd., has been promoted to full lieutenant, after nearly nine months' service in Egypt and Salonica. He was invalided home with dysentry, but we are glad to hear that he is now once more in good health.

Lieut. Courtenay was well known in the electro-journalistic sphere, and the above will be welcome news to his many friends.

Transactions of the Illuminating Engineering Society (Edison Decennial Number, August 30th, 1916).

THIS number is a particularly attractive one, a feature being the series of colour-reproductions, illustrating the novel lighting arrangements at the Panama-Pacific Exhibition. While in the present circumstances decorative lighting is naturally receiving little attention in this country, the novel and interesting methods now being introduced in the United States should not be entirely lost sight of ; they may furnish us with some useful hints for the future.

Another feature is the Address of Welcome addressed to Mr. Thomas Alva Edison, on the occasion of his being created an Honorary Member of the Illuminating Engineering Society, U.S.A. The number is also of interest as marking the Tenth Anniversary of the Society's existence.

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F. NORIE-MILLER, J.P.
General Manager.

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This Coupon must not be cut out but left intact in The Illuminating Engineer as that, being dated, forms the only evidence of its currency.

LANTERNS AND REFLECTORS FOR INDUSTRIAL LIGHTING.

An attractive leaflet issued by the **Wardle Engineering Co., Ltd.** (196 Deansgate, Manchester), illustrates the importance of good industrial lighting. Sketches are presented showing that the use of appropriate units for lighting desks, docks and wharves, over travelling cranes, &c., and attention is drawn to the importance attached to factory lighting by the Government, as an indication that this matter deserves earnest study at the hands of manufacturers.

Among the advantages claimed for scientific light control are :—Less danger ; less fatigue for workers ; happier workpeople ; better work ; greater production ; less cost for ourrent ; greater profits.

A booklet issued by **Engineering and Arc Lamps, Ltd.** (Sphere Works, St. Albans, Herts), also deserves notice. A number of special fittings for use with half-watt lamps are shown, among them being several (the " Britannia," " Clyde," &c.) which seem particularly adapted to industrial lighting. In our last number we mentioned a similar line of fittings brought out by Crompton and Co., and we are glad to see that the design of half suitable lanterns and reflectors for half-watt lamps is now being taken up very generally by manufacturers of electric lighting appliances.

Another novelty brought out by Engineering and Arc Lamps, Ltd., is the "Nevaknot" adaptor, which, as its name implies, is claimed to prevent inconvenient twisting, knotting and tangling of flexible wires.

SHADED LIGHTS.

In view of the demand for proper shading devices in order to comply with the Lighting Regulations it is of interest to notice that special metal reflectors for this purpose are being supplied by **A. E. Podmore and Co.** (34 Charles Street, Hatton Garden, E.C.).

At the present time there is undoubtedly a need for workmanlike metal shades of this kind for gas lamps. Makeshift devices of paper and cardboard give unsatisfactory lighting conditions and are sometimes actually dangerous. The reflectors in question have a polished interior surface and serve the double purpose of screening the lights and directing the rays inwards where they are chiefly needed.

AMERICAN ASSOCIATION OF GAS INDUSTRIES.

We notice that, according to the *Gas Age*, a new organisation, The Association of American Gas Industries, is coming into existence in the United States. Among the objects of the new Association are the establishment of more reasonable, equitable and uniform contract conditions between its members and the Corporations that purchase their product, and the promotion of a higher appreciation on the part of Corporations of the value of the services rendered by its members.

We are informed that Mr. F. J. Roden has resigned his position as Director of The Electrical Supplies Co., and that for the present the direction and control of the business will be vested in the Managing Director, Mr. E. C. Beman;

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by
LEON GASTER

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EDITORIAL.

Welfare Work in Factories.

In this issue we are reproducing (pp. 341-352) the inspiring Paper on "The Human Element in Factories" read by Mr. B. S. Rowntree, Director of the Welfare Department of the Ministry of Munitions of War, at the last meeting of the Circle of Scientific, Technical, and Trade Journalists, together with the ensuing discussion.

Apart from its general interest and extreme importance at the present moment, this discussion should be of special interest to many of our readers, in view of its close relation with much of the work done in connection with illuminating engineering. Mr. Rowntree points out that it is impossible for men to do their best work if the conditions in factories are unsuitable, if the hours of work are excessive, if workers do not receive sufficient nourishing food, and if the rooms in which they work are insufficiently heated, poorly lighted, or badly ventilated. Welfare work, which ensures that the needs of the workers receive proper consideration, is therefore thoroughly justified from the economic as well as the humanitarian standpoint.

Now this is exactly the line of argument pursued from the very commencement of the illuminating engineering movement in this country. The essential idea underlying our propaganda has been that illumination should be considered on its merits as a necessity in modern life, and that the relatively small expenditure involved in lighting a room properly was amply repaid by the greater comfort and convenience secured. The public service to be done in this direction was aptly expressed in the closing sentences of the late Professor Thompson, in his Inaugural Address to the Society in November, 1909, when he said :—

> " I trust, therefore, that before long our Society will become generally recognised as one of public utility, having a real purpose to fulfil. . . . Meanwhile, we have an immediate and direct function to discharge in the collection, discussion, and dissemination of knowledge ; and in arousing the interest of the public and of public bodies to the economic and social importance of the questions for which we are now united to form a Society."

In the case of industrial lighting the influence of illumination is specially evident. It has been shown that insufficient or badly arranged lighting is a cause of spoiled work, leads to fatigue, and tends to increase accidents. This view was endorsed in the Report of the Departmental Committee on Accidents in Factories, and confirmed in the subsequent investigations forming the Report of the Departmental Committee on Lighting in Factories and Workshops which reported last year. The conclusions of this Report were again endorsed in the bulletins issued by the Committee on the Health of Munition Workers.

The recognition of these facts has come about mainly by slow and painstaking work, involving the utilisation of the best channels for moulding public opinion, by concerted action, wherever possible, with associations and societies interested in any particular aspect of lighting, and by securing the sympathetic co-operation of the scientific and technical Press.

The aims of illuminating engineering are closely related to those of welfare work, of which the lighting of factories forms an essential section. We are therefore justified in assuming that much of the experience gained in connection with illuminating engineering will apply to the broader aspects of welfare work, and that similar methods will have to be pursued in order to gain the interest and support of the general public.

Mr. Rowntree's highly appreciated paper before the Circle furnished one illustration of the kind of propaganda work that is needed. It is essential, in the first place, to interest employers throughout the country in the movement. And when this stage has been reached we are still at the beginning of what needs to be done. Welfare work is itself in a state of flux. Those engaged in it are constantly discovering new possibilities and new outlets for their energy. Each experiment should be recorded, and the results of each innovation noted for future use. We hope, therefore, that those associated with the movement will see to it that information regarding each development is made widely known to the Press, in order that they can be kept informed of all its ramifications, and bring them in suitable form before employers interested in their application.

The good seed thus sown will bear good fruit in time to come, and it is our hope that in this respect good will come even out of the present terrible conflict, and that a more cordial relation will gradually be established between employer and employee.

Scientific and Industrial Research in Australia.

Readers will recall that at a meeting of the Circle of Scientific, Technical, and Trade Journalists, on May 16th, an address was given by Mr. Gerald Lightfoot on the Scheme for a Federal Institute of Science and Industry in Australia.

Through the courtesy of Mr. Lightfoot we have since received a series of Reports, issued by the Executive Committee in charge of this scheme, which show that the Commonwealth Government is already taking active steps towards the practical realisation of the aims of such an Institute.

Each State has been requested to form a local Committee to deal with the matter. Circulars have also been drawn up and issued to all the local authorities throughout Australia, asking for particulars of any researches which it is thought would be helpful to local industries, and for information on the resources of existing institutions. Another step in contemplation is the preparation of a Census of Production of the chief industries of Australia.

While, for the moment, expenditure appears to be on a modest scale, the necessary machinery for obtaining such information is now in operation. It will be recalled that one important element in the proposed scheme was the creation of a central Bureau of Information on Scientific subjects. We observe that a small beginning has now been made, a section of the Melbourne Public Library being allotted for this purpose.

An interesting feature of the Report is the reproduction of statements from various localities on researches desired, or already undertaken. Most of these relate to agricultural, pastoral, or mining problems. Naturally the Australian Government may be expected to give precedence to problems connected with their local industries, but the results of their experiments would often have a wider interest, and the assistance of scientists in this country would doubtless be helpful in many cases.

It is our earnest hope that as these movements for the encouragement of research develop throughout the Empire, measures will be taken to secure their co-ordination with each other, and with the Mother Country. We are glad to see that this aspect of the matter has been brought to the notice of the Committee of the Privy Council for Industrial and Scientific Research, which has expressed its general approval of this view and suggested some principles that ought to govern such co-operation.

Meantime, in order that we in this country may be in a position to afford the fullest assistance to the efforts of the Colonies and Dominions, it is essential that the aims of the Authorities should be clear and definite, and that there should be available ample funds to enable researches to be conducted on a large scale.

An important statement on this point has just been made by Lord Crewe to a Deputation from the Conjoint Board of Scientific Societies. It was stated that a large sum is to be allotted to scientific and industrial research which will enable an expenditure four or five times the present vote for the purpose to be made over a period of five years; that additional funds are to be devoted to improving the position of the staff of educational institutions, and that expenditure by firms out of profits on industrial research will receive special encouragement. We shall refer to this matter more fully in our next number.

Street Accidents.

Some interesting figures were officially given recently in reply to a question by Mr. Gilbert, M.P. From these data it appears that there has been a progressive increase in the number of accidents caused by motor vehicles. This is made still more evident when we add the corresponding figures for 1913, which were not included in those given in the House. The totals are as follows :—

Year.	Total number of Fatal Accidents in the London Metropolitan Police District, caused by motor vehicles of all kinds.	Total Number of Non-fatal Accidents in the London Metropolitan Police District, caused by motor vehicles of all kinds.
1913*	424	13,153
1914..	493	14,638
1915..	666	16,366
1916 to Oct. 31st..	509	11,827

*Taken from the Returns on Street Accidents caused by vehicles during 1913, presented to the House of Commons, February 26th, 1914.

The increase during the years 1913, 1914, and 1915 is marked. The figure for 1916 is apparently low, but the two dark months, November and December, are not included, and therefore the data are not comparable.

While these figures are conclusive as regards the increase in accidents since the outbreak of war, they do not furnish all the information we need in order to establish their relation to the lighting conditions. It must be remembered that the number of motor vehicles traversing the streets, and also the number of people using them at night, are doubtless considerably less than in pre-war days. Furthermore, the speed of motor vehicles is probably less, greater care is exercised both by drivers and pedestrians, and statistics indicate a marked tendency towards sobriety (which is naturally conducive to the safety of pedestrians) since the outbreak of war. The authorities have also taken special measures for the safety of the public, such as the recent recommendation that the rule " keep to the right " should be adhered to more closely.

In spite of all these facts the number of street accidents tends to increase. The alteration in illumination—not only as regards diminution but, also the extreme contrasts that prevail in some streets—is doubtless one important factor in the causation of accidents. With a view to developing greater uniformity of method, it would be a great advantage if, during the war, the lighting of London could be placed under a single authority, acting under the best expert advice.

With a view to establishing conclusively the relation between accidents and illumination, it would be useful if the following additional data could be furnished, or, if not at present available, collected in the future :—

(1) The returns of the accidents during *each month* of the period referred to above.

(2) The respective numbers of accidents in each month during the day, and between sunset and sunrise.

(3) The dates at which further restrictions in lighting have been introduced.

(4) The approximate figures for the number of licensed motor vehicles, tramcars, etc., plying in London in each month.

(5) The dates at which restrictions, if any, in the speed of such vehicles, have been introduced.

Information on these lines would be of great assistance to lighting authorities in the future in determining the best method of illuminating the streets, and the regulation of the speed of traffic.

LEON GASTER.

A LOGARITHIMIC ILLUMINATION CHART.*

The representation of distribution of horizontal illumination between two lamps spaced a considerable distance apart is attended with some difficulty. In general the illumination falls away very rapidly as we recede from the base of the lamp, until, midway between the lamps, it may be but a small fraction of that immediately underneath them. If, therefore, we select a scale sufficient to show the higher values, differences in the mid-point illumination become almost unrecognisable, and to the uninitiated there appears little difference in the performances of two types of unit, although one may give twice or three times the minimum illumination of the other.

The question is of greater importance nowadays in view of the tendency to lay stress on the minimum illumination provided in a street, as suggested in the Draft Standard Specification of the Joint Committee on Street Lighting, presented by Mr. Trotter before the Illuminating Engineering Society in 1913. Moreover, during recent years much more attention has been given to the design of units giving more uniform lighting conditions. After the war, when street lighting in this country will doubtless be more scientifically studied, the possibilities of such units will be closely studied.

It is, therefore, of interest to notice a method of exhibiting distribution of illumination devised under the supervision of Mr. W. D'A. Ryan in the laboratory of the General Electric Co. (U.S.A.). It is pointed out in a Report on this method that several years ago it was seldom necessary to calculate illumination at points further from the lamp than ten times its height. A lamp suspended 15 feet above the street did not, as a rule, give satisfactory minimum horizontal illumination beyond 150 feet (*i.e.*, 0·006 ft.-candles at a distance equal to ten times the height of the lamp. But units are now being designed, particularly those of the prismatic glass type, which, when suspended at the above height, will produce this illumination at a distance of 180—240 feet. For example, in one such unit, having a polar curve specially designed for street lighting, the intensity at 80°—84° is increased from 1,300 to 2,100 candles, while the downward component is decreased from 500 to 100 candles. The distribution of illumination is thus more uniform and the lamp is effective for a proportionally greater distance.

In such cases the conventional method of depicting distribution of illumination has, as stated above, distinct drawbacks. Sometimes the scale of the curve may be changed as the distance increases, with a view to showing more clearly what happens in the more remote parts, but the breaks in the continuity of the curve are a bad feature destroying its fundamental simplicity, and leading to possible misunderstanding and confusion. In order that such curves may be used by a salesman when approaching customers, the curve should be an actual picture of results.

Now the "ultimate consumer" in judging street lighting, is not guided by considerations of "candle-power" or "foot-candles," but by the physiological impression derived from the illumination produced. The sensation varies as the logarithm of the illumination, and this in itself furnishes an argument for presenting results with a logarithmic scale.

The chief advantages of such a scale are:—

(1) An unbroken curve over great ranges of illumination.

(2) A single scale for the entire curve.

(3) It makes practicable the use of a fixed standardised web for all street units.

(4) There is uniform accuracy throughout.

(5) The sensation values are pictured in a manner that gives a reasonably accurate impression.

The great majority of illumination curves, possibly ninety-nine per cent., have for their equations some simple form such as

$$E_h = \frac{I\alpha}{H^2} . \cos^3\alpha \quad \ldots \quad \ldots \quad (1)$$

for horizontal illumination,

$$E_n = \frac{I\alpha}{H^2} . \cos^2\alpha \quad \ldots \quad \ldots \quad (2)$$

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*Based on a Report presented by W. D'A. Ryan of the Laboratory of the General Electric Co. (U.S.A.), in 1915.

for normal illumination,

$$E_s = \frac{K.I\alpha}{H^2} . \cos^3\alpha \quad .. \quad (3)$$

for the illumination along a vertical surface such as a wall.

The above equations can be easily applied in a logarithmic form, thus :—

$$\log E_h = \log I\alpha + \log \cos^3\alpha - \log H^2 \quad .. \quad (4)$$

$$\log E_n = \log I\alpha + \log \cos^2\alpha - \log H^2 \quad .. \quad (5)$$

$$\log E_s = \log K + \log I\alpha + \log \cos^3\alpha - \log H^2 \quad (6)$$

The suggested chart is simply a device for adding and subtracting logarithms, as indicated in the above equations. The operations do not involve logarithmic calculations and are carried out on the same principles as on a slide rule.

The full page illustration is a reproduction of a typical logarithmic chart. In the top right-hand corner is a candle-power web. This, however, plays no direct part in the operation of the chart. Candle-power values are usually plotted at intervals of ten degrees and may be recorded on the space down the right-hand side of the chart.

At the bottom of the chart are two spaces occupied by curves that are similar in shape but have different spacings. The lower set of curves are used for obtaining normal ilumination, the upper for horizontal illumination. At the extremities of these spaces are scales for various heights of lamps varying from ten to twenty-five feet. The curves give the expressions appearing in equations (4)–(6).

A straight line drawn from any height, say 21 feet, on the left-hand height scale to the same height on the right-hand height scale will intersect the horizontal curves at distances proportional to :—

$$\log \cos^3 0 - \log 21^2$$

$$\log \cos^3 10 - \log 21^2$$

$$\log . \cos^3 88'' 33' - \log 21^2$$

Similarly for the "normal" curves.

The sloping lines in the middle of the chart are spaced according to the logarithms of the intensity of the light in candles. The length of a vertical line drawn from the candle line is proportional to log I. To the left is a scale of foot-candles. Across the top of these intensity lines is a radial distance scale that extends to 500 ft.

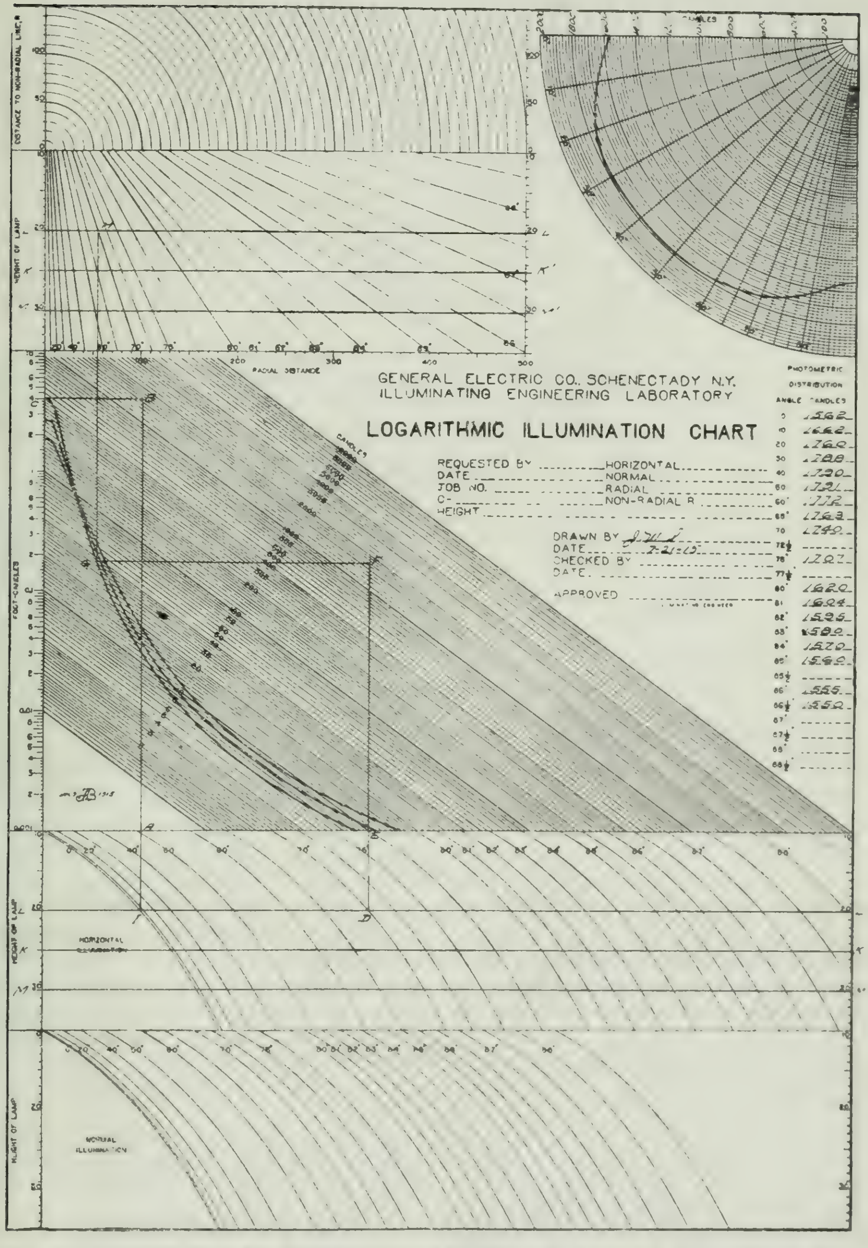
The set of straight lines above the distance scale are "tangent" lines. A straight line drawn through 21 on the scales at right and left intersects the tangent lines at distances that are proportional to the distances (from the base of the lamp) at which the rays from the lamp strike the street.

At the top of the chart is a set of arcs of circles that may be used to find the illumination along a line that does not pass beneath the lamp. These arcs of circles replace the arcs of ellipses used on the old form of illumination chart. Illumination along any line within one hundred and fifty feet may be obtained by use of these arcs.

In the illustration actual candle-power values are shown plotted in the right-hand corner, and down the right-hand edge. Suppose now that the horizontal illumination for heights of 20, 25 and 30 feet are desired. Starting with the 20 feet height the straight line, LL, is drawn through the 20-feet marks on the scalesat the ends of the set of "horizontal" curves, and also a similar line, L′L′, at the same height on the set of tangent lines. A set square is placed with the vertical side through the intersection of the line, LL, just drawn and the zero degree horizontal curve. The intensity 1562 is then plotted at B on the candle scale vertically over the intersection point I.

The height, AB, of the point located is equal to the logarithm of the illumination as measured on the scale on the left. The point at which this intersection occurs is directly beneath the lamp and the point C on the illumination curve is obtained.

In a similar manner another point, G, on the illumination curve, is determined for 70 degrees, using the line L′L′, G being the intersection of lines FG and HG. The extension of the process, using lines KK, K′K′, MM, M′M′, etc., gives results for heights of 25 and 30 feet respectively. In dealing with normal illumination we may first obtain a horizontal illumination curve and then move it bodily up and down a distance corresponding with log K. Thus if the value of K were 0·4 the curve is moved up until the point



GENERAL ELECTRIC CO., SCHENECTADY N.Y.
ILLUMINATING ENGINEERING LABORATORY

LOGARITHMIC ILLUMINATION CHART

REQUESTED BY ____ HORIZONTAL ____
DATE ____ NORMAL ____
JOB NO. ____ RADIAL ____
C- ____ NON-RADIAL R ____
HEIGHT ____

DRAWN BY J. W. L.
DATE 7-21-15
CHECKED BY ____
DATE ____

APPROVED ____

PHOTOMETRIC DISTRIBUTION

ANGLE	CANDLES
0	1562
10	1662
20	1760
30	1788
40	1720
50	1721
60°	1772
65°	1763
70	1740
72½	
75°	1707
77½	
80°	1620
81	1604
82°	1595
83°	1580
84°	1570
85°	1560
85½	
86°	1555
86½	1550
87°	
87½	
88°	
88½	

FIG. 1.—Complete Chart for Determination of Illumination Curves on a Logarithmic Scale. (Mr. W. D'A. Ryan.)

0·4 foot-candles coincides with 1 foot-candle on the chart.

On a standard blue print the curve plotted to a logarithmic scale may have a range of 10—0·001 foot-candles, which suffices for all ordinary purposes. The accuracy of the graphical arrangement compares very favourably with that obtainable on the old form of illumination chart, and is uniform throughout the scale.

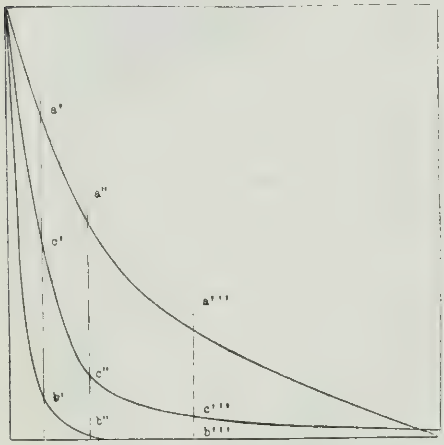


FIG. 2.—Showing a′ a″ a‴ Illumination Curve plotted to logarithmic scale.

b′ b″ b‴ Illumination Curve plotted to linear scale.

c′ c″ c‴ Sensation Curve plotted to linear curve (coeff. of reflection 0·30).

In fig. 2 are plotted side by side illumination curves to a linear and logarithmic scale and the sensation curve assuming a coefficient of reflection of 0·3. The great advantage for distant points is demonstrated. The difference in shape of curves a′ a″ a‴ and c′ c″ c‴ is doubtless due to the Purkinje effect which begins to operate below 0·1 foot-candle.

ACCIDENTS IN THE STREETS.

In reply to a question by Mr. Gilbert, Mr. Herbert Samuel has given the following statistics relating to the number of people killed in the Metropolitan Police District through street accidents in the course of 1914, 1915, and up to October 31st in the present year:—

No. of persons killed by—

Year.	Tramway Cars.	Motor Omnibuses.	Other Mother Vehicles.
1914	37	148	308
1915	86	154	426
1916 to Oct. 31	63	135	311

No. of persons injured—

Year.	Tramway Cars.	Motor Omnibuses.	Other Mother Vehicles.
1914	3,171	3,007	8,460
1915	4,001	2,572	9,793
1916 to Oct. 31	3,085	1,810	6,937

In the same periods, the number of accidents caused by tramcars was 5,254, 6,142, and 4,594 respectively; by motor omnibuses 6,521, 4,981, and 3,394; and by other motor vehicles 20,150, 21,913, and 15,988.

It will be observed that the period up to October 31st, omitting the two dark months of November and December, hardly gives a full indication of conditions in the present year, and it must also be remembered that the number of persons using the streets at night, and also the number of vehicles, is probably much less than before the war.

PARIS TO BE LIGHTED BY CANDLES.

Paris, "La Ville Lumière," is now experiencing yet a further diminution in illumination. According to a recent decree of the Prefect of Police the shops and stores are not to be lighted after six o'clock in the evening by gas, electricity, petroleum or spirit. An exception is made in favour of shops dealing in foodstuffs, druggists, hairdressers and tobacconists. Shops are not compelled to shut at 6.p.m., but if they remain open after this time they must find other means of lighting.

Another reform is the closing of cafés and restaurants from 9.30 onwards.

THE UNLIGHTED STAIRS.

Sir Thomas Tacon is confined to his bed suffering from sprains to both knees caused by falling down a staircase while on his way to attend a meeting of the Eye Tribunal There was no light near the stairs.

LIGHTING IN THE ARMY.

The Illuminating Engineering Society in the United States is evidently applying its attention closely to lighting problems in connection with naval and military matters. We recently gave an account of some points raised in a recent paper by Lieut. McDowell on "Illumination in the Navy." The October issue of the *Transactions* of the Society contains a similar address by Capt. Ed. D. Ardery on lighting in connection with army work.

There is no doubt that in many of these fields experts on lighting could make useful suggestions. Most of the remarks made in this paper would no doubt meet with general agreement. While gas and oil, as well as electricity, are used for lighting officers' quarters and barracks, open flames are naturally considered inadvisable in the neighbourhood of magazines. Acetylene is well adapted for tents utilised for clerical work, but it is recommended that the flame should be kept within a chimney with a view to avoiding flickering. For trench-digging, road-repairing, &c., acetylene portable outtfis may be useful, and a light fed from a small acetylene generator, slung on the back of the leading man, is useful for indicating the line of march of columns moving in the dark. (While these remarks may apply to home service the necessity for concealing movements from the enemy may, however, modify considerably such methods in actual warfare. The problem of providing sufficient light for work, without attracting attention, is not an easy one, and proper shading devices would seem essential. Capt. Ardery mentions that in view of these considerations army lanterns so used are specially constructed to throw light downwards.) Another device mentioned is the attachment of light-coloured objects to the backs of the belts of the men, so that, on a dark night march, they will find it easier to keep their distance.

A rather curious appliance used for hunting in the Philippines is the attachment of small acetylene lamps to the head, with the light immediately over one eye. The eyes of a deer brightly reflect this light and appear as fiery discs, making it easy to sight between them.

Among other matters dealt with the author emphasises the need for alternative systems of supply at points of importance. Thus at the sea coast forts in the United States there is in many cases an electric generating plant on the premises as well as facilities for using the town supply. It is also common practice to install 25 k.w. gasoline plants near the batteries.

It is stated that the local abnormal air pressures set up by the firing of big guns often extinguish gas lights or oil lanterns, and electric lights are therefore preferable.

The illumination of gun platforms presents many special problems, as it is by no means easy to secure the proper conditions of illumination and, at the same time, to avoid the eyes of the men being dazzled by exposed lights.

The remainder of the article deals with the use of searchlights, a matter which was also covered in the paper by Lieut. McDowell.

DEVELOPMENTS IN SEARCHLIGHTS IN THE UNITED STATES.

In the recent paper by Lieut. McDowell before the Illuminating Engineering Society (U.S.A.) on " Illumination in the Navy "* mention was made of the new searchlight with cooled electrodes being developed in the United States. Some further particulars are now given in the *Electrical World*.

One of the new searchlights is mounted on the Sperry Building, Brooklyn, N.Y. It is stated that the beam is visible 50 miles away, and that attempts will shortly be made to signal over a distance of 91 miles. The source of light is stated to be not the incandescent crater, but a superheated vapour within it, obtained by using impregnated carbons. An intrinsic brilliancy exceeding 500 c.p. per sq. mm., or more than 320,000 c.p. per sq. inch, is obtained ; this is 65 per cent. of the brightness of the sun at 30° elevation and nearly 3½ times the brilliancy of the pure carbon arc crater. At the same time the area of the crater has been diminished, giving a more concentrated beam.

The following particulars of the lamps are also mentioned :—

Current.	Type of Lamp.	Diameter.		Consumption of Positive Electrode.	Illumination produced at a distance of ½ mile.	Equivalent Candle-power.† (approx.)
		Positive Electrode.	Negative Electrode.			
					ft.-candles.	
150 amps.	36″	⅝ in.	$\frac{7}{16}$ in.	13·5 in. per hr.	30	210,000,000
200 ,,	60″	slightly larger	slightly larger	—	85	550,000,000

It is stated that in the case of the 200-amp. arc the dispersion does not exceed one degree. Unlike the Beck lamp, this new lamp is not cooled by means of alcohol but by the agency of a blast of air which is forced up through the hollow electrode supports and impinges on the electrode. In view of the small size of the source, it is important (1) that the source should be maintained in a symmetrical condition, (2) that its position with respect to the focus of the minor should be unaltered. The first requirement is met by a small motor which keeps the electrode in continuous rotation, the second by using a differential thermostatic device which automatically keeps the arc within 1½ millimetres of the focal point.

OUTDOOR PAGEANT LIGHTING ON A LARGE SCALE.

A recent number of the *Lighting Journal* (U.S.A.) describes the novel artificial lighting conditions required for the outdoor performance of the mammoth pageant " Caliban " performed at the Stadium of the College of New York. The Stadium is circular and has a seating capacity of 20,000. The stage-area is 80 ft. long, 20 ft. deep, and 40 ft. high, and was illuminated by a series of gas-filled lamps in projector-reflectors, situated a distance of 300 feet. These lamps required in all about 1400 amperes.

The colour and intensity of light could be readily adapted to the requirements of the performance, and it is said that the lamps were so well situated that the source of light was not at all noticeable. The fact of gas-filled lamps being used was helpful in enabling all lighting effects to be controlled from a single switchboard at the back of the stage.

During the arrival of the audience they were prevented from seeing what was happening on the stage by the use of several 1000-watt lamps in glass-lined reflectors, which were turned towards them, producing a " mild blinding in the direction of the stage, thus acting as a complete screen or curtain of light."

One may doubt if this form of screen will be found generally acceptable to audiences, even if contrived on the most efficient and up-to-date lines.

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* *Illum. Eng.*, Sept., 1916.

† Calculated from preceding column.

CIRCLE OF SCIENTIFIC, TECHNICAL, AND TRADE JOURNALISTS.

THE HUMAN ELEMENT IN FACTORIES.

(Discussion at a meeting of the Circle of Scientific, Technical, and Trade Journalists, held at 5 p.m., on Tuesday, November 14th, in the Hall of the Institute of Journalists, Tudor Street, E.C.)

THE Annual Meeting of the Circle took place at the Institute of Journalists at 4.30 p.m. on Tuesday, November 14th, when a report on the proceedings during the past session was presented by the Chairman, and accepted. In view of the attention now being paid by the Circle to the question of Technical Education and Industrial Research, and the importance of preserving continuity in this work, it was resolved that the Officers and Committee for the past session should be re-elected.

At 5 p.m. a General Meeting of the Circle was held in the Hall of the Institute, Mr. L. Gaster being in the Chair.

In introducing Mr. ROWNTREE, the speaker for the evening, the CHAIRMAN referred to the great industrial changes that had taken place since the outbreak of war, especially in connection with munition work, which had rendered the study of conditions of work in factories of vital importance. The work done in this direction by the Welfare Department of the Ministry of Munitions was of great national value, not only in promoting better and more hygienic conditions of work, but in bringing about more cordial relations between employer and employee. The Circle was very fortunate in hearing Mr. B. S. ROWNTREE, the Director of this Department, whose experience on the matter was unique. The nature of this work deserved to be more widely known, and the scientific and technical Press could render valuable aid in this direction.

Mr. B. S. ROWNTREE (Director of the Welfare Dept., Ministry of Munitions) then read his paper on "The Human Element in Factories" (see pp.343—347). Welfare work, he pointed out, might be defined as "the humanising of industrial conditions." In the old days when industry was conducted in small factories, the employer knew his workers personally and took an interest in them. In the huge factories of to-day this is no longer possible. Hence welfare departments are being organised in many factories, and many hundreds of welfare supervisors have been appointed since the outbreak of war. Mr. Rowntree described in detail the work undertaken by such supervisors, and mentioned cases in which their efforts had quite revolutionised conditions of work, bringing about better relations between the employer and the staff, and materially improving output and quality of work. "No method of conducting industry," he added, "is satisfactory which leads to a waste of human effort, and unless workers are happy and contented and well they cannot put forth their best efforts."

At the conclusion of Mr. Rowntree's address the CHAIRMAN read extracts from a number of letters expressing regret at inability to attend and interest in Mr. Rowntree's work. These included communications from Viscount HALDANE, the Rt. Hon. ARTHUR HENDERSON, and Mr. A. G. GARDINER (President of the Institute), while Sir WILLIAM LEVER, Sir RICHARD BURBIDGE, and Mr. GORDON SELFRIDGE, as large employers of labour, expressed the view that good work could only be accomplished when cordial relations were established between management and staff.

A vote of thanks to Mr. Rowntree was proposed by Mr. A. J. MUNDELLA (Chairman of the London District), and seconded by Mr. GILBERT WOOD, and a discussion ensued in which Mr. A. T. DALE, Mr. G. BELLHOUSE, Mr. E. H. PELHAM, Mr. A. P. M. FLEMING, Dr. E. L. COLLIS, Miss L. E. PATTERSON, Miss A. A. SMITH, Miss B. O'REILLY, and Mr. S. R. LITTLEWOOD took part.

Mr. ROWNTREE, in replying to the discussion, expressed his pleasure in addressing the Circle, and the hope that the scientific and technical Press would cooperate in making the importance of the subject more fully recognised by manufacturers.

CHAIRMAN'S INTRODUCTORY REMARKS.

The CHAIRMAN (Mr. L. Gaster): The subject on which Mr. Rowntree is about to address us is one not only of great present moment, but of vital importance to our industrial future.

The great crisis through which we are now passing has served to emphasise the importance of careful study of conditions of work in factories. Large masses of men, women and children have been removed from their normal conditions to do unfamiliar work in novel circumstances and at exceptional pressure. Those at work in the munition factories are giving their utmost in health and strength.

The welfare movement, therefore, satisfies an admitted need. I do not wish to anticipate what Mr. Rowntree is going to tell us of the admirable work of the Welfare Department of the Ministry of Munitions. Some of you, however, are familiar with the series of bulletins on such subjects as hours of work, housing, canteens, heating, lighting and ventilation, etc., which the Committee on the Health of Munition Workers has been issuing during the past and present year. These bulletins have shown by actual facts and figures how impossible it is for workers to do their best if they are overworked, underfed, and badly housed. They have demonstrated in a most convincing manner that even from a purely economical standpoint it pays to care for the welfare of the worker, and to see that he is comfortable and contented.

I do not, however, wish to refer to the movement on this ground alone. The country is rightly bending all its energies on the immediate task before it. And yet we must think of the future as well. If bad conditions of work prevail, especially among the women and children now engaged in industry, they will not only prove uneconomical now, but will prejudice the physique of the nation and of future generations in the future.

Neither do we regard the welfare movement as beneficial only because it increases the worker's capacity and is therefore profitable. From a wider standpoint this movement ought to appeal to us as a ground of common contact between capital and labour, as work in which both must participate if genuine success is to be obtained, and as an indication of the spirit of co-operation which will lead the worker to feel that his or her work is a service to the country, and a source of legitimate pride.

The many lessons we are learning from this terrible war will surely not be forgotten when the conflict is at an end. That there are great industrial changes to come after the war we most of us believe. That they will be accompanied by fuller co-operation and the coming of a more cordial and friendly spirit between employer and employee we all of us hope. Not the least useful approach to these better conditions is by the aid of the welfare work, on which Mr. Rowntree is going to address us to-night.

We, as journalists, can do a share of the good work. It is only by much patient educational effort that the country can be brought to recognise the vital importance of this subject. And even when manufacturers are united in desiring guidance there is still the problem of finding out and making known the exact conditions of work that give the best possible result from the economic and hygienic standpoint. The scientific and technical Press is in a particularly happy position to act as a channel for the dissemination of such knowledge. We therefore will look to Mr. Rowntree for information, and for suggestions as to how we can best serve the movement under his direction.

Mr. Rowntree's long experience of this work will be known to many of you. Even before the war he was identified with the study of the welfare of factory workers, and had introduced in his own business the essential principles of what is known to-day as welfare work. This past experience has enabled him to render inestimable services to the country at the Ministry of Munitions, and we are indeed fortunate in welcoming him here to-night.

THE HUMAN ELEMENT IN FACTORIES.

By B. S. Rowntree.
Director of the Welfare Department, Ministry of Munitions of War.

(Paper read before a meeting of the Circle of Scientific, Technical, and Trade Journalists, held in the Hall of the Institute of Journalists, London, at 5 p.m. on November 14th.)

I was asked to speak on "Welfare Work in Factories," but instead of adopting that title for my address I chose "The Human Element in Factories," for welfare work may be defined as the humanising of industrial conditions.

As I travel about the country I am impressed by the fact that whereas very many employers recognise fully that their responsibility to their workers extends far beyond the bare observance of the Factory Acts, and the payment of the rate of wage current in the locality, others contend that they see no need to do more than fulfil these two conditions. "Business is business," they tell you. "The workers care nothing for us, why should we bother about them?" And so they frankly treat their workers as impersonal dividend-producing machines. Are they happy or unhappy, well or ill, anxious or contented, matters not so long as they can do their work; and after all, if they don't or can't do their work there is always the remedy at hand, and others ready to take their places. Having definitely adopted this attitude towards the workers, they not infrequently proceed to complain bitterly of their behaviour. "They break time shockingly, and with utter disregard to the importance of the work." "They waste material." "They are for ever grumbling; their sole aim is to get as much as they can for doing as little as possible. They strike on the least provocation, or without provocation, and merely at the bidding of some agitator. In short, they are a lazy, shiftless lot."

Now in certain factories there is much truth in many of these charges. But what a terrible waste of that precious commodity, human effort, this indicates. To think that men should be idling when England is fighting with her back to the wall!

I suppose there never was a time in our national history when there was greater need for every one of us to do and be his best, and for the elimination of waste. "Don't waste gas, coal, or electric light," is an admonition placarded over the London hoardings in letters 4 feet high. "Don't waste human effort" is an admonition much more urgently needed. And not needed to-day only. It will be needed for long years to come, when we are engaged on the unromantic and uninspiring task of paying a war bill of no one knows how many thousand millions.

And so we come to this. Present conditions have forced upon us the fact that if the nation is to prosper, human effort, the basis of prosperity, must be economised. By this I do not mean, of course, held back, but used to the best possible advantage.

The wheels of the industry must be greased, for truly our industrial system is a groaning, creaking machine, and much in need of oil.

I do not propose here to discuss fundamental changes in it, their consideration falls outside the scope of welfare work. But I want to make it clear that no method of conducting industry is satisfactory which leads to a waste of human effort, and that unless workers are happy and contented and well, they do not and cannot put forth their best efforts.

Briefly, welfare work aims at making the workers happy, contented, and well. Not, mark you, by fair words and tinsel rewards given in lieu of the more substantial rewards for effort which trade unions demand, but by providing such conditions of industry, and showing such consideration for the workers as naturally call forth effort. This, of course, includes rewarding effort suitably—or, in plain business language, paying good wages. Welfare work and sweating wages are like oil and water: they won't mix.

And now let me seek to define more precisely what I take welfare to involve. I have already referred to wages. I think it will be agreed that the minimum aimed at should be wages sufficient to provide what is necessary for physical efficiency and to leave a reasonable margin for recreation. I do not propose to quote figures. I have done this elsewhere, but I maintain that the employer should seek to satisfy himself on this head, and should regard the conditions in his factory as essentially unsatisfactory until at least this minimum has been reached. And here I would urge that what is of importance to the workers is not the wage rate, but the sum of money actually taken away week by week. Care should be taken to avoid standing individuals off work for such periods that the wages they take home at the week-end are insufficient for the maintenance of physical efficiency. It is really astonishing how some employers stand workpeople off without paying them, without apparently recognising the hardship involved, or making any adequate effort to regularise employment. The evil of this practice is magnified when workers are living away from home; and in the case of girls living in lodgings, the temptation to earn money in other ways is obvious.

Another fundamental condition of well being is that the length of the working week should not be excessive. The working day should be of such total length and so divided up by rest intervals as not unduly to tax the workers' strength, and it should give reasonable opportunities for rest and recreation. In no case should the hours be more than recommended by the Health of Munition Workers' Committee, and if a shift is as long as five hours it should be broken by a brief rest interval. Accurate statistics of the wastefulness of excessive hours of work are very difficult to obtain, owing to the instability of working conditions, which make comparison of output during periods of short hours and long hours unreliable; but there is a growing concensus of opinion that long hours, especially if continued for a considerable period, do not pay the employer. In this connection it is important to remember that once the human organism becomes run down it takes much longer to rebuild the worn-out tissues than to wear them out; the Health of Munition Workers' Committee has recently published a memorandum giving the result of a detailed and careful inquiry which they have made into the matter. They give various illustrations of the economy of short hours. For instance, they show how, in one munition factory, a reduction in hours, from 77¼ to 66½ per week, resulted in an increased hourly output of 23 per cent. in the case of female workers; and they say in regard to this case that the evidence pointed to 60 hours per week as being the maximum number of hours which can be worked with advantage. In another case the hourly output of men increased by 22 per cent. when their hours were reduced from 71 to 61 hours per week.

A third factor of great importance in the well-being of the workers is that there should be adequate facilities for securing nourishing food under restful and wholesome conditions. When considering the energy put into their work by factory employees, it is sometimes forgotten that, as Walker, the American economist, pointed out, there is only one way of getting energy out of a man, and that is by first putting it into him. If a man's food is adequate his work may be mighty; if he is underfed he must underwork. And yet not a few employers regard the provision of nourishing food in suitably furnished canteens as a luxury. It is no more of a luxury than is the stokehole of the boiler-house. And let it be remembered that it is not sufficient just to put the necessary amount of nutriment into the man or woman. The dinner hour should be spent under agreeable and restful conditions. To eat a cold or heated-up meal, sitting by one's machine, in a close or dirty workroom, is not the way to secure a good afternoon's work. Clean and wholesome workrooms, well lit, and well ventilated, and work suited to the capacity of the worker are other conditions both of welfare and of efficiency. Thus stated the fact would appear to be obvious, and, yet it is one which is frequently overlooked in practice. We know in our offices that if the light is trying, or the air is close, we cannot do our best work, and yet how ill-lit and ill-ventilated are many workrooms! And again, how often men and women are put to work for which they are not suited.

This leads me to another important matter, namely, the method of selecting employees. It seems to me that employers do not sufficiently realise how critical a process of industry the "setting on" of a worker is. This is true of all workers, but especially of women and boys. Imagine girls or boys introduced for the first time into a large factory! They should first be led to realise the great possibilities that lie before them, and then surrounded by conditions which will enable them to realise those possibilities. Engagement should always be by a sympathetic person, with the gift of inspiration, who should keep in touch with the workers after engagement, with a view to supplying the sympathy and stimulus which encourage them to do their best. For a foreman to pick a boy or girl out of a crowd and send them to work in a merely mechanical way, without any recognition of the fact that the human mechanism is extraordinarily sensitive and responsive to external stimuli, is not the way to economise human effort. I said earlier on that for men and women, and especially boys and girls, to put forth their best efforts they must be happy, contented, and well. To achieve this end they must be treated and considered individually, and not in the mass. Rough justice for a large factory staff may comprise a great many minor cases of injustice, and each one of these militates against the efficiency and output of the person affected. A foreman giving to nagging or bullying is the worst investment an employer can make. As has been well said, "In business hearts, not clubs, are trumps."

How is this individual attention to employees to be secured? In the old days, when industry was conducted in small units, and the employer knew his workers individually and called them by their Christian names, there was a human bond of relationship between master and man. Now, with enormous factories employing thousands of men and women, this bond has largely disappeared. The directors base their policy largely on financial considerations, and the workers tend to become only pawns in the financial game. It is obviously impossible for a large employer, however much sympathy he may feel with them, to know his workers individually, and that is why employers have introduced into their factories what are often known as welfare departments, staffed by carefully selected men and women, whose duty it is to seek to introduce into the business organisation that human touch which is so apt to be squeezed out in the huge industrial concern of to-day. The staff of the welfare department usually engage the workers, or at any rate assist in doing so, possibly leaving the ultimate choice to the foreman or forewoman; they keep records of broken time, and seek to remove its causes; they investigate cases of dismissal and resignation of employees; they hold a watching brief over the wages, and advise the management where any case of injustice or anomaly seems to exist; they investigate complaints made by the workers; they supervise the working conditions, and, especially where poisonous or dangerous materials are handled, seek by every means to safeguard the health and safety of the workers; they supervise the canteens and rest-rooms, and where workers are imported from a distance they help in finding suitable lodgings. In short, they seek not only to secure good working conditions, but to show consideration to each individual worker. They are not concerned, as a rule, with technical processes or output, though obviously if they succeed in creating a spirit of contentment and good-will their work affects output very greatly.

Hundreds of such welfare supervisors have been appointed since the war began, and many an employer can testify to the value of their services. Of course, there have been failures. It is obvious that in work of this kind everything depends on the personality of the officers appointed, and where the choice has been unfortunate the work has suffered accordingly. But the failures have been few in comparison to the successes. I have seen the whole character of a working staff revolutionised through the tactful activity of a welfare department. Only the other week I went over a large factory where a couple of thousand women were employed—many of them on most unpleasant and dangerous work and yet there was throughout the whole place a striking spirit of good-will and contentment. I learned the secret of this in the course of an hour's talk with the head welfare supervisor, who told me of the care taken to secure the best possible working conditions, and of the individual attention paid to the workers. She told me of the great benefits which had been derived from the appointment of refined and sympathetic women as supervisors.

The following is a summary of the work carried out:—

(1) The engagement of women, and recruiting labour from the Labour Exchanges.

(2) The supervision and care of the overalls used by workers.

(3) The appointment of twelve carefully selected welfare supervisors.

(4) The consideration of all complaints and the checking of all dismissals.

(5) The work of the hospital, where there are up to 800 cases per week, and of the dentistry department.

(6) The constant supervision of health precautions.

(7) The supervision of canteens, cloakrooms, etc.

Before I close, I should like to take the subject of humanising factory conditions a stage further, and speak of what I believe is to be the next step in the evolution of industry. Hitherto the position of employers and employed has been almost purely that of master and servant, and yet, when one comes to think of it, there is no reason why this should be so. The employer either provides or represents capital, but his capital is valueless without labour, just as labour is valueless without capital. To make either effective they must come together and work in co-operation. Why should they not work in a spirit of partnership? Is there anything to prevent the realisation of the ideal outlined by Mr. Gosling in his presidential address to the recent Trade Union Congress, where he said: " We hope for something better than a mere avoidance of unemployment and strikes. We are tired of war in the industrial field. The British workman cannot quietly submit to an autocratic government of the conditions of his own life. He will not take ' Prussianism ' lying down, even in the dock, the factory, or the mine. Would it not be possible for the employers of this country, on the conclusion of peace, when we have rid ourselves of the restrictive legislation to which we have submitted for war purposes, to agree to put their business on a new footing by admitting the workmen to some participation, not in profits, but in control? We workmen do not ask that we should be admitted to any share in what is essentially the employer's own business—that is, in those matters which do not concern us directly in the industry or employment in which we may be engaged. We do not seek to sit on the board of directors or to interfere with the buying of materials, or with the selling of the product. But in the daily management of the employment in which we spend our working lives, in the atmosphere and under the conditions in which we have to work, in the hours of beginning and ending work, in the conditions of remuneration, and even in the manners and practices of the foremen with whom we have to be in contact—in all these matters we feel that we, as workmen, have a right to a voice—even to an equal voice—with the management itself. Believe me, we shall never get any lasting industrial peace except on the lines of industrial democracy."

Up to the present, employers have tended to keep the workers at arm's length in all questions of management. " If I can't be master in my own business, it is about time I shut up shop," has been their attitude. I am confident that it is a wrong one, and it must be changed if we are to be successful in the intense industrial competition to which we must look forward in the future. There have been many signs in the past decade that English workmen, with their growing education and width of outlook, will not much longer be contented to be mere wage slaves. The industrial conditions of the last two years have made them see clearly how indispensable are their services to the community, and they will claim a more responsible part in determining the industrial conditions of the future. It will, I believe, be a profound mistake for employers to hold the trade union at arm's length, and to resent all suggestions that the workmen should have a say in determining, not the financial policy of business, but the conditions of work. It will not weaken, but strengthen, British industry to have this closer co-operation.

Let us say to the workmen: "Come and help us in a spirit of partnership to solve the day-to-day problem connected with the conduct of our business." We will establish Works' Councils on which workers and management shall be equally represented. Since the decision of these councils might occasionally be incompatible with the financial policy of the business, the management, who are ultimately responsible for finance, must retain a vote over them; but, on the other hand, the trade unions may discuss with the management any decision come to by the Works' Council not satisfactory to them. There is nothing in this suggestion which need alarm either capitalists or trade unions, but the frank recognition that the workers within certain limits are regarded as partners rather than servants at once raises their whole status. The existence of Works' Councils, where all kinds of questions of management can be frankly discussed and suggestions received from the workers for overcoming difficulties, will do much to break down that suspicion which leads not only to serious industrial unrest, but which checks output and lowers efficiency.

I should like, if I may, to conclude with a quotation from a remarkable book by an American writer named "Redfield," entitled *The New Industrial Day*. Speaking of the human element in industry, he said:—

"With the men that enter our factories, enters the greatest force in all production, I mean the responsiveness of these men to leadership. They work indeed because they needs must earn their bread, and it is needful that supervision should be closely exercised for manifest reasons, but neither the need for bread nor the closest supervision will draw out the best that the workman has to give. That can only be done by the righteous adjustment of wage to product; by the absence alike of injustice and of charity; by the opening of the door of opportunity; by the absence of driving and the presence of leading; by the selection of the man for the task, and the adjustment of the task to the man; by the instruction of the man for his task or, if unfitted for it, then in some other task for which he is more fitted; by the spirit of candour and frankness between the employer and the worker; by the willingness to hear and to wait; by the closest possible touch practicable in great factories between the management and the working force. It has been said that corporations have no souls; this is a pity, if true, for the men in the shop have souls, and the coming in to the minds and hearts of the men that run the corporations of sufficient soul to give them a basis for appeal to and co-operation with the souls of men at the machines may make the difference between profit and loss to the corporation."

Since I took up my work at the Ministry of Munitions it has become increasingly clear to me that the work of the Welfare Department is largely one of education. I have come across manufacturer after manufacturer to whom the views I have placed before you are a new gospel. Some of them receive it with gladness, some with suspicion, and some with opposition—the opposition of the man who is firmly convinced that what was right for his grandfather cannot be wrong for him. The suspicious men, and those who are at first in opposition to us, do not really lack sympathy; but from one reason or another they have got into a rut, which has proved to be a grave to modern ideas. Most of them, I feel sure, can be persuaded in time to humanise the conditions in their works, but they must be *absolutely convinced* that this is the right thing to do before they change their methods. It is impracticable for my department to conduct the necessary educational campaign by means of individual conversations. What is needed is the creation of a public opinion throughout the country, which regards the impersonal and mechanical method of dealing with workers as out of fashion and unwise, and which demands a more human relationship between employer and employed.

I am here to ask you to help me in the creation of this public opinion. You have opportunities for doing this which no one else possesses. It is a great work to undertake, and may have far-reaching influences, not only on the health and happiness of countless thousands of workers, but upon the success of British industry in the period of intense competition which undoubtedly lies ahead of us.

DISCUSSION.

Before declaring the discussion open the CHAIRMAN (Mr. L. Gaster) read a number of letters received, expressing interest in Mr. Rowntree's paper, and regret at inability to be present:—

Viscount HALDANE:—

"I wish I could have been present on the 14th to hear Mr. Rowntree's paper, but a public engagement will detain me elsewhere.

"The subject is a very important one from the point of view of the training of the future generation. The work at the Ministry of Munitions in which Mr. Rowntree is engaged is of special importance."

The Rt. Hon. ARTHUR HENDERSON, M.P.:—

"I desire to acknowledge the receipt of your letter of the 31st of October, and to express my regret that the pressure of official duties prevents me from being present at the meeting of the Circle of Scientific, Technical, and Trade Journalists on Tuesday.

"Mr. Rowntree's work as Director of the Welfare Department of the Ministry of Munitions needs no recommendation. That work marks a definite departure from the view which has too often held the field, viz., that the physical well-being of his workers was no concern of the employer. From this vicious principle Mr. Rowntree broke away, and the results of his labour at York have proved an object-lesson to all employers of the present day.

"The Welfare Department of the Ministry of Munitions is doing work of incalculable value to the future well-being of our country.

"I trust you may have a successful gathering."

Sir WILLIAM LEVER:—

"I know of no one who can better address the meeting on this subject than Mr. Rowntree. He and his firm have done so much for the welfare of their staff. The whole basis of welfare work consists in the employer doing something for the benefit of his staff that they cannot do for themselves. Only the employer can provide within the precincts of the factory the arrangements on which their welfare depends. Such arrangements do not entail great capital expense, but they do involve some little thought. Whatever capital and thought are so expended will be amply repaid by the improved health, efficiency and happiness of the staff."

Mr. H. GORDON SELFRIDGE:

"In this subject I take a great interest. One of the great underlying principles of management of large bodies of employees is to treat them with fairness and justice, and also with that kindly and reasonable consideration which the manager would himself hope for if he were in the place of the employee. Labour which is won through fear is half-hearted, but that which is won through love and respect is genuine and sincere, and if the staff is led by inspiration it will give more nearly 100 per cent. of its possible efficiency than when controlled by any other method."

Sir RICHARD BURBIDGE (Managing Director, Harrods Ltd.):—

"I very much regret that a prior engagement prevents my hearing Mr. Rowntree's paper. Welfare work is always of great interest to me, and I am convinced that any time and thought given by the employer to studying the well-being of workers is amply repaid by increased efficiency. It may be interesting to you to know that we consider the health and comfort of our employees in a very practical way. There are well-lit dining-rooms, comfortable rest-rooms, permanent nurses' rooms, and a visiting doctor and dentist are provided. Some five years ago a training scheme was instituted, and employees are given time off during the day to attend classes. By analysis of the common error we are able to provide classes in the subjects which are most needed."

Mr. A. G. GARDINER (Editor of the *Daily News* and President of the Institute of Journalists):—

"The subject is one of supreme importance at this moment, and I congratulate your Circle on the advantage of being addressed by the highest authority on the question. I sincerely trust you will have a profitable discussion."

The Rt. Hon. DAVID LLOYD GEORGE (Minister of War)

"regrets that owing to great pressure he is unable to be present at the meeting."

Mr. MONTAGU (Minister of Munitions)

"regrets that his engagements will prevent him from being present. He is sure, however, that Mr. Rowntree's well-known authority on the subject with which he is to deal will secure the success of the meeting."

Sir GEORGE NEWMAN (Chairman of the Committee on the Health of Munition Workers):—

"expresses thanks for the invitation, but will not be able to attend, as he is absent in Scotland on official business."

Among others interested in the subject who had been invited to the meeting, but had been unable to be present, may be mentioned: The Home Secretary, Sir Arthur Whitelegge (H.M. Chief Inspector of Factories), Sir George Riddell, Mr. G. H. Roberts (Labour Adviser to the Board of Trade), Mr. C. W. Bowerman, M.P., Sir Hedley le Bas, Mr. J. L. Garvin

(Editor of the *Observer* and President Elect of the Institute of Journalists), Sir James Yoxall, Sir Henry Trueman Wood, Dr. Chas. Carpenter, Mr. Arnold Bennett, Mrs. Sidney Webb, Mrs. H. J. Tennant, and Miss R. E. Squire.

The CHAIRMAN (Mr. Gaster) after referring in appreciative terms to Mr. Rowntree's interesting paper, added that he would like to endorse Mr. Rowntree's remarks regarding the value of good lighting in factories, that being a subject in which he was personally concerned. This question had received insufficient attention for many years, but in 1913 the Home Office appointed a Departmental Committee to inquire into the matter and, in spite of the war, had issued a preliminary Report in three volumes, which was certainly far ahead of anything published hitherto. This report had received the attention of the Committee on the Health of Munition Workers, and had been endorsed in the bulletins issued by this Committee. Thus, the question of lighting was looked upon as a very important one in welfare work because it had been clearly shown that good lighting was influential in increasing the output and diminishing the number of accidents.

Mr. A. J. MUNDELLA (Chairman of the London of the Institute of Journalists), who proposed a vote of thanks to Mr. Rowntree, agreed as to the great importance of welfare work. The chief question was how to obtain and train welfare workers. He was confident, however, that under Mr. Rowntree, with his great experience in this direction, a real team of efficient workers would grow up. It was a great sacrifice and very noble of him to place himself at the disposal of the Government in this matter, and journalists should now come forward and do a little bit more towards the progress of the welfare movement than they had been doing hitherto.

Troubles and misunderstandings between workmen and employers were frequently exaggerated in the newspapers, and difficulties were thus placed in the way of an amicable settlement. He hoped that Mr. Rowntree's eloquence and impressive explanation of the situation would encourage journalists to try to put a little more imagination into this matter in order to help to bridge over the chasm between employer and employee.

Mr. GILBERT WOOD (Vice-President of the Institute of Journalists), who seconded the vote of thanks, said that although they had not all seen eye to eye with Mr. Rowntree, or rather with the suggested movement, in the past, the position as it had been explained by Mr. Rowntree indicated that this difference of opinion was very often due to ignorance.

It was clearly desirable to educate the employer but at the same time the employees also had to be educated. As an instance of this, he mentioned that as far back as 25 years ago a big firm of printers suddenly came to the conclusion that their place was unhealthy and decided to make improvements; an expensive system of ventilation was put in, but the employees did not recognise its value and within a week the whole of the ventilators were stuffed up and the place was more unhealthy than it was before.

With regard to the class of employer who said that what was good enough for his grandfather was good enough for him, unfortunately that type of man nowadays often did not even go through the works as did his grandfather, but went to a university instead and came back to take control of a business of which he knew nothing. It was impossible for a man of this type to realise what was necessary for the benefit of the workpeople and the difficulties with which they had to contend. Therefore, the welfare movement must aim at making the welfare supervisor fill the place of the master in such matters, introducing the element of personal contact that was characteristic of relations between master and man in the old days.

Mr. A. T. DALE, as an employer who had at one time 5,000 men working for him, agreed that the old personal contact between master and man, when most of the employees were called by their Christian names, led to better relations between them than did the present conditions of large factories in which the employers could not possibly know their workpeople. Everything should be done to create good feeling not only between the employees and the employers, but amongst the employees themselves and it was in this direction that welfare work must play an important part.

Mr. G. Bellhouse (Factory Dept., Home Office) said Mr. Rowntree in his work at the Ministry of Munitions was laying the foundation for a system which must be a permanent feature in the future. The conditions years ago when factories were small were very different from those of the big joint-stock companies of to-day, and it was becoming more and more necessary for welfare work to be developed in workshops and factories.

One of the chief points in Mr. Rowntree's paper was the need for education. He was quite satisfied that if this work was going to be a success a vast amount of education would have to be carried out. It was necessary to educate the employer, because there were no doubt some employers who looked upon welfare work as "philanthropic rot." Then it was necessary to educate the welfare superviser, because it was not practicable to put any man or woman to this work without proper education. The work required infinite tact, for the supervisor had to act in a sense as a go-between between the employer and operative without representing either, and must obtain the confidence of both.

Then it was necessary to educate the operatives because at the present time some were looking with considerable suspicion upon welfare work. They did not quite know what it all meant and argued that if the employer put a welfare supervisor in the works at a salary of £250 a year he must be getting something out of it and out of themselves. That arose from a misconception of the real nature of welfare work. To counteract such impressions it was necessary to create a public opinion in favour of welfare work; otherwise it might become unpopular and even a failure. There was little doubt that welfare work had received during the war a stimulus such as it had never had before, and Mr. Rowntree was one of the principal agents who had brought this stimulating influence to bear.

Mr. E. H. Pelham, Secretary of the Committee on the Health of Munition Workers, regretted that the Chairman of this Committee had been prevented from being present. He would like to say, however, that great credit was due to Mr. Rowntree for initiating the work done in this direction.

Mr. A. P. M. Fleming said that there were two aspects of welfare work—one was materialistic, and the other, for want of a more appropriate term, might be called the ethical aspect.

By the materialistic aspect he referred to the preparations made for improving the well-being and physical comfort of the worker such as had been set forth in the paper. In this connection he would refer to those researches relating to the physiological and psychological conditions governing fatigue, and which relate to the efficiency of workers. Considerable work had already been done in this matter and discussed at the last two meetings of the British Association, and he hoped that a great deal more research work of this character would be carried out in future, since it afforded the most promising means of solving scientifically problems that are at present attempted by mere guess work.

By the ethical aspect, he had in mind the development of an inherent desire on the part of workers for improved hygienic and environmental conditions in factories in place of a complacent acceptance, which at present prevails on the part of a large mass of workers of any conditions—good or bad—in which they find themselves. The time at which to start the development of the ethical side of welfare work is not with the adult worker, but with the boy or girl just prior to, and for a few years subsequent to, leaving school, for while much can be done to develop good habits in adult workers by suitable environment, it must be remembered that in many industries such workers are often migratory, and the good effects of a well-equipped factory are readily lost. In particular, attention paid to the development of the social interests of boys by encouraging sports and other social activities, is likely to have far-reaching effects in imparting a desire for suitable working environment.

Dr. E. L. COLLIS, also a member of the Committee, spoke in terms of admiration of Mr. Rowntree's work. He mentioned, as an instance of the value of personal interest in employees, the case of a young foreman whom he met again after eight years but did not recognise. It appeared, however, that some words of encouragement of his given to this young man eight years before had remained in his mind and served him in good stead, for he had made rapid progress and had been made foreman at a very early age.

Miss L. E. PATTERSON said she had been immensely struck during a tour of factories by the enormous influence of the women supervisors on the girls and women. They were quite willing to come to the supervisor and state any grievances, and had found her of the greatest service to them. This welfare work was of niestimable benefit in munition factories, where she had found the women workers were extremely happy. Similarly the hostels were admirably organised. In one instance there was a woman doctor who told her that not only did the workpeople come to her for advise in the ordinary way at the works, but they also consulted her on many of their worries and troubles in home life.

Miss A. A. SMITH, who had also visited a large number of factories in company with Miss Patterson, expressed her admiration of the great influence exerted, not very demonstratively, but absolutely and sympathetically by the lady supervisor in charge. It gave her great pleasure also to hear Mr. Rowntree and the other speakers recognise the very great service that had been done by women in public life. But would Mr. Rowntree sweep away the impression which had gained ground in certain quarters that the assistance of the welfare worker was being paid for out of the employees ? Also would he state whether there were as many men welfare workers as women and were the women welfare workers paid equally with the men ?

Mr. S. R. LITTLEWOOD spoke of an instance of conflict of interest between those responsible for the erection of a picture palace in connection with one of the large munition factories and the local Y.M.C.A., who looked upon this step with disfavour. At the same time it frequently happened that when there were no such picture palaces an enormous number of young people who were now at work on munitions flooded into the towns and were without any means of recreation at all.

Miss BRIDEY O'REILLY said that many educated women suitable for the post of welfare supervisor were unable to accept the positions on account of the length of hours which many employers seemed to think they should work. They were, however, quite willing to work half the number of hours for half the salary. Would it not be possible to appoint two supervisors to cover the factory hours, one working, say, from 7 a.m. to 1 p.m., and the other from 1 p.m. to 7 p.m. ?

The vote of thanks was then put to the meeting and carried with acclamation.

Mr. ROWNTREE, replying briefly to some of the points raised, dealt first with the education of employees as to the advantages of welfare conditions. He quite agreed that this education is necessary, but it was most important that they should not expect gratitude from the workers. Welfare conditions were really not charity. They were nothing more than a fulfilment of the reasonable responsibilities of the employer, and if those interested entered upon the work with the idea that they were particularly virtuous persons and expected gratitude from the employees they were bound to be disappointed. Nevertheless, the education of employees was necessary to enable them to appreciate these things, and it was quite as important as the education of the employer.

With regard to sweeping away the idea that the welfare supervisor was paid out of the wages, he knew that the work was looked upon with a considerable amount of suspicion by trade union leaders who thought it was an attempt to side-track trade unionism, and to give the workers little lollipops and presents in place of substantial rewards for their labour. It was, however, very important indeed that it should be understood that it was nothing of the kind. This was not an attempt to interfere with the organisation of labour, and had nothing whatever to do with any attempt to pacify workers, and get them to be contented with conditions which were unsatisfactory. Some of the employees had the feeling that the supervisor was paid out of their wages, and was put into the works merely in order to get more work out of them, but that, of course, was not the case.

Welfare supervision had not been introduced to get more out of the workers. It was based primarily on the idea that the men and women employed must have their conditions of employment considered, and although incidentally it had been found that this consideration for their employees paid the employers, yet he was sure it had not been primarily introduced because it paid. On the other hand, it was not done as philanthropy, but merely as a piece of business organisation.

With regard to men supervisors and their salaries, he had plenty of vacancies, but unfortunately nearly all the men were engaged in France. He could place a dozen good men to-morrow if he had them, and if any one knew a good man would they send him along to the Ministry of Munitions? With regard to salaries, broadly speaking, they were about on the same scale for the women as for the men, although he knew of one case where the head woman supervisor got exactly double the salary of the head man.

The need for recreation mentioned by Mr. Littlewood was a very important matter, and he was glad it had been mentioned because the whole question of recreation was now being dealt with by the Welfare Department at the Ministry of Munitions. They had already begun to organise in certain munition centres recreation. They were encouraging the people to provide their own recreation and entertainments, and he discouraged the idea that they should have ready-made entertainments flung at them. He hoped that would be developed on an extended scale.

As to length of hours for the supervisors, that was really a matter which each employer must determine. It was a condition of employment which he must make with the supervisor. What he thought was reasonable was that these supervisors should work what he would call office hours. The work of the welfare supervisor was very arduous, because he or she was always giving out sympathy, and there was nothing more wearying than that. It certainly could not be done for twelve hours on end, and he therefore suggested office hours, whatever they might be according to the district. Many employers did expect the welfare workers to keep the same hours as the factory employees, but he considered these were often too long.

As to having two people to work through the day, he thought that such a scheme would result in them being looked upon as amateurs. The girls would say that if they could "stick" twelve hours of it, there was no reason why the welfare supervisor could not, and on the face of it that was a sound criticism.

He was glad that Mr. Bellhouse had supported the work. He wished to make it clear that the ideas he (Mr. Rowntree) had been putting forward had not originated with himself. He was merely the humble agent of others who wished those ideas put forward, but they would not fructify throughout the length and breadth of the land unless there was a public opinion which demanded this attitude on the part of employers towards their employees. The Home Office could not do it, the Health of Munition Workers Committee could not do it, and the Ministry of Munitions could not do it. They could, it was true, send a travelling inspector down to speak to any particular employer, and that might make a little bit of impression.

But the only way to do it thoroughly and universally was by getting a public opinion throughout the country, and the only people who could do this were those with influence in the Press. If the Press demanded that such an attitude should be displayed by employers, it would be an enormous help. Therefore, he most earnestly asked those who had power and influence in the Press to develop the right atmosphere for such ideas as he had had the privilege of putting before the meeting.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

A NEW BRITISH INDUSTRY.

Heat-Resisting Glassware for Lamps and Lighting Appliances.

During this year **Messrs. Chance Brothers and Co., Limited** (Glass Works, near Birmingham), have devoted much energy to establishing in their works the manufacture of glass of heat-resisting qualities, such as is required for globes for intensive lighting, and which, previous to the War, were only to be obtained from enemy countries. In taking up this entirely new branch of the glass trade, Messrs. Chance were influenced chiefly by the urgent representations made to them by the Board of Trade.

We understand that they have succeeded in making a glass similar to the Jena glass, and are to-day sending out globes which are proving in every respect equal to, or better than, the German product, and that they are now seriously going into the trade on permanent commercial lines.

Z ELECTRIC LAMPS.

An attractively-got-up pamphlet has been issued by the **Z Electric Lamp Co., Ltd.** (Southfields, London, S.W.). In the introduction it is pointed out that the War has shown the necessity of this country being self-supporting in vital supplies, such as lamps and accessories for artificial light ; since the outbreak of War there has been an increased demand for British goods of this kind.

B.T.H. INCANDESCENT ELECTRIC LAMP HANDBOOK.

The Incandescent Electric Lamp Handbook (No. 1), now issued by the **British Thomson-Houston Co., Ltd.,** is of a handy pocket-size, and contains a great deal of useful information. Illustrations of all the chief lamps (one-third full size) are shown on the left-hand pages, with corresponding particulars of wattage, candle-power, size of bulb, etc., facing them on the right hand. There is also a complete list of definitions of terms used in the incandescent lamp trade.

The list includes an explanation of the "Lumen," and it is pointed out that there is a growing tendency to describe the performance of a lamp in terms of "lumens per watt" rather than "watts per candle." We notice that throughout the booklet values in lumens as well as watts per candle are given, while the general table of candlepower values (p. 14) gives the watts, watts per candle, mean hor. candlepower, total lumens, lumens per watt, and spherical reduction factor. The booklet is completed by particulars of the dimensions of standard lamp caps, both of the screw and bayonet type.

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SEARCHLIGHT PROJECTORS.

The latest list of searchlight projectors issued by Messrs. Crompton and Co. contains evidence of the rapid developments in this field. Some of the most interesting developments, however, naturally cannot be referred to at the present time (we notice, for example, the omission of several illustrations in deference to the Defence of the Realm Act).

Of special interest are the constant improvements being made in appliances for the manipulation of searchlights and their elevation in different directions. We observe in this list rows of 24 in. anti-aircraft projectors and compact forms of motor field service equipment. A convenient form of mobile projector is shown in Fig. 2. Among the various special attachments may be mentioned motor-controlled flashing shutters, Parsons Split Mirrors, cable carts, petrol generating sets, &c.

While most of the illustrations naturally refer to types of searchlights specially adapted to war requirements it is of interest to note that they have many other special applications in peace both for marine work and on land. Small projectors, for example, may be fitted to river steamboats, and, as Fig. 3 suggests, searchlights are often useful for facilitating night operations in mining work.

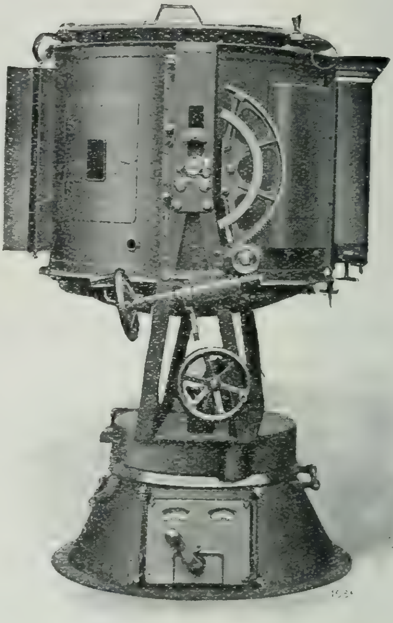

FIG. 1.—Anti-Aircraft Projector.

We notice that reference is made to "the absence of any recognised standard as a basis of comparison for the effective range" of searchlights, and the view is expressed that the relative merits of searchlights cannot conveniently be expressed in terms of candle-power. We recognise the difficulties, but it is surely desirable that some common method of expressing the illuminating effect on a distant object should be available. We hope that manufacturers will not overlook this possibility. This matter deserves closer investigation. Considerable progress in the desired direction has already been made and the problem may prove less difficult of solution than is commonly supposed.

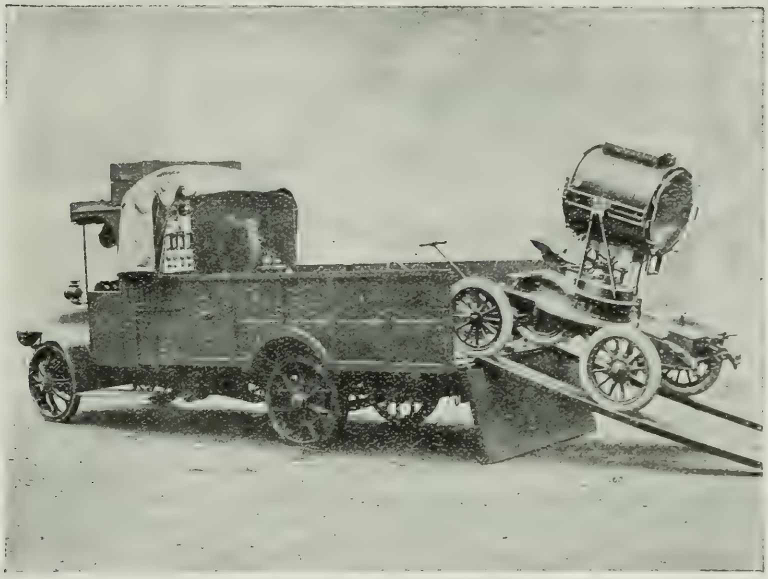

FIG. 2.—Complete Mobile Projector Equipment.

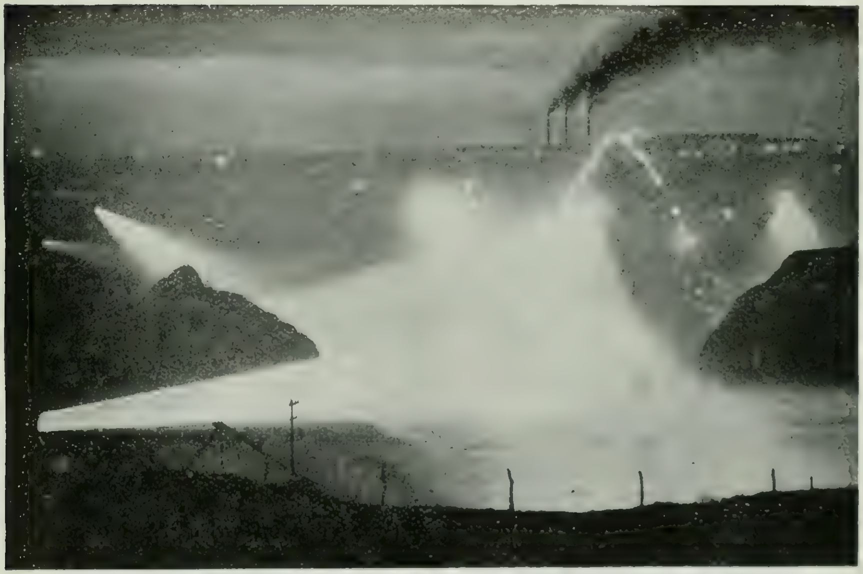

FIG. 3.—Projectors for Night Operations in Mines.

CORRESPONDENCE.

To the Editor of the ILLUMINATING ENGINEER

COST OF DAYLIGHT *vs.* ELECTRIC LIGHT.

DEAR SIR,

There seems to be so much misapprehension, particularly amongst architects, as to the point that daylight costs nothing, and so much tendency to sacrifice valuable space to secureday light illumination when artificial lighting could provide illumination far more effectively and cheaply, that I would like you to give me sufficient space in your columns to publish the following letter written by Mr. M. Luckiesh of the Laboratories of the National Electric Lamp Association of Cleveland, to the *Lighting Journal* of New York.

"In lighting discussions it is not uncommon to hear such statements as this: 'A great virtue of daylight is that it costs nothing.' Outdoors this is usually true, but in the vast field of human activities where artificial light aids and competes with natural light, such a statement is absurd. From the standpoint of construction, openings such as windows and skylights are not costless In other words, interest upon a permanent investment as well as a maintenance cost must be charged to the daylighting, and therefore at once it ceases to be free from cost. Furthermore, when the value of land, especially in large cities, is considered, a light court in the middle of a multi-storied building adds to the cost of daylight. In such a case a large area of rental space is sacrificed for the purpose of admitting daylight, and it appears that the cost of daylight would not be inconsiderable. Of course, light courts provide ventilation, but it seems possible that ventilation could be provided without such a great sacrifice of space.

"The discussion could be carried further to the consideration of valuable wall space in stores where rental prices are high, and possibly even in factories.

"By no means is this comment designed to suggest the abolishment of daylight even in cases where it might be found too costly, but rather to suggest that some architect, who may have figures available, favour us with a discussion of the cost of daylight."

Yours, &c.,
F. W. WILLCOX.

ROYAL SOCIETY OF ARTS.

SESSIONAL ARRANGEMENTS.

The programme for the coming session contains many interesting items. There are lectures on such subjects as "The Economic Development of Russia," "The Coal Tar Industry," "Classical and Scientific Education," "The World's Cotton Supply," "German Business Methods," etc. The Howard Lectures are to be delivered by Prof. J. S. S. Brame, on "Coal and its Economic Utilisation," and by Professor W. Ripper on "Works Organisation and Efficiency." The Cantor Lectures will be by Prof. Beresford Pite on "Town Planning and Civic Architecture."

REVIEW OF BOOKS.

Spon's Electrical Pocket Book, by W. H. Molesworth. (Messrs. E. and F. N. Spon, Ltd., 57, Haymarket, London, S.W. 1916. 6s. net. 488 pp., 325 illustrations.)

THIS little booklet contains a great deal of useful condensed information. There is a liberal allowance of illustrations, and an adequate index.

The early part of the book is devoted to the usual mathematical and conversion tables, logarithms, &c., after which we have particulars of electric mains, and sections on Insulation and Resistance, Continuous and Alternating Machinery, Electrochemistry, Traction, &c. One interesting feature is the reproduction of the Italian graphic symbols, with appropriate Italian, English and French wording applied to represent various instruments, appliances and conditions in electrical technology.

In the section on lighting the matter is brought up to date by the inclusion of data on the gas-filled lamps, and even the recently introduced arc-incandescent lamp. Some figures for the illumination of various classes of premises and the lighting of streets and railways are also given. The data on railways, however, appear to be taken from information published in 1906 and might, perhaps, be supplemented by particulars from more recent papers before the Illuminating Engineering Society. Similarly, in regard to streets, the classification in the Draft Standard Specification for Street Lighting might be included. Some fuller reference to industrial lighting and the Report of the Home Office Departmental Committee would also be welcome. Finally it may be suggested that the design of reflectors, and their division into extensive, intensive, and focussing types might, in a future edition, be explained.

The section of tramways and electric railways appears to be fully dealt with, and the work is concluded by a reproduction of the I.E.E. wiring rules.

PUBLICATIONS RECEIVED.

The Transactions of the Illuminating Engineering Society (U.S.A.) for October contain papers on the following:—"Lighting in the Army," "The Selection of a Standard Unit in Commercial Lighting," "The Artificial Illumination of Interiors as related to Architecture and Decoration: Gas Lighting in a Cathedral."

The Journal of the Franklin Institute (October) contains an interesting address by Mr. Walton Clark entitled "A Century of Light," tracing the development of illumination in the United States since 1815.

Among recent bulletins of the *Bureau of Standards* may be noted:—No. 60 on "Electric Units and Standards," in which the evolution of the various units is explained and the practice of various countries summarised; No. 292 on "International System of Electric and Magnetic Units," a suggestive contribution by J. H. Dellinger, forming a useful supplement to the above; and No. 277 on "An Interlaboratory Photometric Comparison of Glass Screens and Tungsten Lamps involving Colour Differences."

The Proceedings of the American Philosophical Society (Vol. LV., No. 6, 1916) contains a contribution by Dr. E. D. Nichols on the "Phosphorescence of certain Metallic Sulphides."

Colour (October, 1916) contains a series of striking coloured reproductions of landscapes and studies of various kinds. The "Portrait of an Eastern Dancer" is not without interest as an example of spectacular lighting effects.

FATIGUE, AND ITS EFFECTS ON INDUSTRY AND EFFICIENCY.

(*Chadwick Public Lectures, delivered on October 27th, November 3rd, and November 10th, by Professor E. Stirling, M.D., D.Sc., LL.D.*)

THESE lectures, which were delivered before a numerous and appreciative audience at the Royal Society of Arts, were devoted respectively to (1) The Physiological Basis of Fatigue; (2) Some Industrial Aspects of Fatigue; and (3) Fatigue—a Universal Phenomenon of Life.

It was shown how even the simplest operations cause faitgue of the muscles, the brain, or the senses, how recuperation takes place, and how, if the strain is too severe or prolonged, the recovery is proportionately slow. One of the many ingenious devices for measuring fatigue is the ergograph, by means of which the power of raising a weight by the fingers is graphically recorded. Professor Stirling showed a great number of diagrams obtained in this way, many of which illustrated the effect of excessive fatigue in diminishing the available muscular effort and retarding the recovery to a normal state. Others showed the long-continued effects of a muscular strain, and the lowered vitality resulting from semi-starvation and insufficient sleep.

All of this has a direct bearing of factory operations, and the lecturer was able to show, by such diagrams, how important it is to allot periods for recuperation on a scientific plan, in order to get the maximum output. Some instructive diagrams were presented, based on data obtained both in British and French factories, showing how with increasing hours of work, the output becomes stationary and even falls off; how accidents tend to rise steadily after the interval for refreshment, and tend to a maximum about 5 p.m., shortly before the working day terminates. Equally interesting was a diagram indicating how the output of workers is prejudicially affected by over-indulgence in alcohol.

The lecture was illustrated by cinematograph films, showing operations in munition factories, and the conditions in and behind the trenches at the Front.

HEALTH AND HYGIENE.

A leaflet under the above title, issued by the Incorporated Institute of Hygiene, contains a variety of interesting notes, written in a condensed but popular manner, relating to health.

It is stated that in Germany a serious form of blood-poisoning, due to continual feeding on preserved foods ("tin-sickness"), has been making its appearance; that soft caoutchouc artificial eyes are now being substituted for glass on account of their greater convenience and flexibility; that recent Zeppelin raids have annoyed the cows, and prejudicially affected the supply of milk; that while many rich people are economising by buying margarine instead of butter, many workers, who are receiving higher wages than before, are doing the exact reverse.

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F. NORIE-MILLER, J.P.
General Manager.

INDEX, November, 1916.

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Signature ....

This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

HEALTH OF MUNITION WORKERS' COMMITTEE.

Two additional bulletins have been recently issued by this Committee. Memorandum No. 11 contains a Report by Dr. Leonard Hill on "An Investigation of Workers' Food and Suggestions as to Dietary"; Memorandum No. 14 deals with "Washing Facilities and Baths."

Dr. Leonard Hill discusses the conditions determining the wastage that requires to be made good by daily consumption of food, and analyses the constituents of common meals into protein, fat and carbohydrate. Specimens of daily dietaries from hostels and canteens are reproduced. Finally a suggested daily dietary for munition workers, together with the cost of each meal, is presented.

One receives the impression that if meals of this kind were universal there would be little to complain of on the score of dietary. In works where well-stocked canteens are provided the care and expense involved must be amply repaid by the better health and work of employees.

Memorandum No. 14 contains some very practical suggestions on bathing and washing facilities—a matter which in the past has undoubtedly been badly neglected in many large factories. We notice that the shower or douche bath is strongly recommended, a view which, we believe, is in accordance with the best Continental experience.

THE BRITISH COMMERCIAL GAS ASSOCIATION.

The Fifth Annual Meeting of the British Commercial Gas Association took place in the Hall of the Royal Society of Arts on November 1st, the chair being taken by the President (Sir Hallewell Rogers). Mr. F. W. Goodenough (Chairman of the Executive Committee) presented the Annual Report for the past year, from which it appears that the Association is maintaining its full activities in spite of the inevitable difficulties of war-time. During the past two years of war it has added about seventy new undertakings to the list of those giving support, which now number nearly 500.

This is a record which must be very gratifying to the supporters of the Association, and particularly to its enterprising and energetic Chairman, Mr. Goodenough. We notice, too, the President's reference to the action taken in Birmingham, where there is now a laboratory with a staff of chemists to whom general problems relating to gas supply and manufacture may be referred.

Of special interest is the recent formation of a National Gas Council, which is intended to be a body representative of the entire gas industry, and which, no doubt, will, among other things, devote itself to the encouragement of research. When one considers the vast ramifications of the gas industry in this country one cannot but be struck by the opportunities for concerted effort. The formation of the British Commercial Gas Association has been fully justified by the experience of the last few years, and no doubt by the time the war is over there will be many other instances of co-operation to record.

ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by
LEON GASTER

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EDITORIAL.

The Visit of the Scientific and Technical Press to Liverpool and Manchester Universities.

In previous issues of the *Illuminating Engineer* accounts have been published of the visits, arranged through the Circle of Scientific Technical and Trade Journalists, to the Imperial College of Science in London, and subsequently to the Universities of Leeds and Sheffield. These visits formed part of a movement for the promotion of closer relations between the Universities of the country and the scientific and technical press.

On pp. 379—386 we now give an account of the visit to the Universities of Liverpool and Manchester, which took place on December 10th—13th. On this occasion, also, the proceedings were full of interest. All were struck by the way in which the work of each University is moulded by the needs of the city it represents. Thus at Leeds and Sheffield, both great industrial centres, the respective spheres of work have a close relation with the local textile, dyeing and steel industries: at Manchester cotton-spinning and engineering receive special attention, and at Liverpool, as a great shipping and commercial centre, we find in the creation of a School of Commerce, the Department of Geography, and in the famous School of Tropical Medicine yet other illustrations of the intelligent study of local needs. It was interesting to see that at all the Universities visited the importance of a knowledge of foreign languages was recognised, special attention being commonly devoted to Russian and Spanish.

Yet the broader aspects of a University's work, involving the provision of a general liberal education, were not overlooked. Equally interesting is the growing tendency towards co-operation between the Universities and other local educational institutions. Thus at Liverpool, we were given to understand, a conference has been considering the co-ordination of the work of the Engineering Department of the University with the technical schools, and in these deliberations the shipping industry of Liverpool is represented. At Manchester, again, we have in the University and the Municipal School of Technology two complementary institutions which work hand in hand. In his address previous to the inspection of the latter, Principal Garnett explained that, as regards the regular courses of study, the School acted as a part of the University; but at the same time it provides evening and other special facilities for study for those who are occupied with their vocation and are not free to follow a full course of study.

The visit to the two cities was so crowded with interesting items that it is impossible to enter upon a description in this note. Readers will find on pp. 379—386 a full description of the proceedings, although even in this account much has been inevitably omitted. The inspection of this varied work was a revelation to the members of the party, and should have a beneficial broadening influence on the technical journalist. Most of those present were primarily concerned with the treatment of their special subjects at the Universities. For example, those associated with hygiene and medicine were keenly interested in the School of Tropical Medicine at Liverpool, representatives of engineering and electrical papers with the Engineering Departments at both Universities and the Manchester School of Technology, while to others the chemical departments, the cotton-spinning, printing and paper-making plant had a special professional interest.

Yet one could see that the members of the party took an almost equally great interest in the sections of work outside their own immediate sphere, and this was due in no small measure to the admirable and lucid expositions of the Professors in each department. Scientific and technical journalists, as a body, now take an interest in general questions affecting scientific education.

In conclusion it only remains to express our great appreciation of the kind attention shown by Professor Gonner (Deputy Chairman of the Senate of Liverpool University), Sir Henry Miers (Vice-Chancellor of Manchester University), and Mr. Garnett (Principal of the Manchester School of Technology), and the professors of these institutions. Acknowledgment should also be made of the courtesy of the British Westinghouse Electric and Manufacturing Co. and the Ford Motor Co. in inviting the party to visit their interesting works. The visit will long remain a most agreeable memory to all the members of the party.

From the Elementary School to the University.

A most encouraging sign during the past few months, coming as it does in the midst of this period of strain and anxiety, has been the general recognition that the educational system of the country needs overhauling. The future of the country is dependent on the efforts we can make now to secure a properly organised system connecting the elementary schools, the secondary and technical schools, and the Universities.

One of the greatest drawbacks under which the educational system of this country has suffered has been the want of co-ordination—the gaps between the higher education and the lower. The country has never lacked men of great ability and distinction in the higher branches of science and industry. At the other end of the scale we find the workers on the whole industrious, painstaking, of good physique and with a certain inherited aptitude for craftsmanship. But the intermediate link, the army of educated capable men to act as foremen and managers, has been missing.

It is therefore gratifying to notice that in the schemes being presented by various educational bodies, this fact is invariably recognised. It was referred to in the programme of the Educational Reform Council and the Workers' Educational Association, in the "Report on Reforms necessary in National Education," presented in the last number of the Journal of the British Science Guild, and in the scheme now presented by the National Union of Teachers.

In many other respects also, these schemes are in substantial agreement. One of the most important suggestions is that local authorities shall institute a system of compulsory classes for young persons between the ages of 14 and 18. The evils of the present conditions are manifest. A child is educated up to a certain point, and leaves school at the age of 14. He goes into employment, often forgets what he has learned and ceases to take much interest in intellectual pursuits. It is of vital importance to our industrial future that a large proportion of such youths should continue their education during these critical years.

The next step is the provision of adequate opportunities for gifted youths to proceed to the University. This need could usually be met by the liberal provision of bursaries and scholarships, which besides meeting the fees for tuition, should enable the recipient to live in comfort and thus remove the natural but shortsighted anxiety of parents that he should immediately earn money.

Liverpool University, with its magnificent endowment of over £1,000,000, is in a particularly good position to pursue an independent course in education. It was stated that no boy of ability, however poor his parents, is debarred from proceeding by steps from the elementary school to the University. But all cities are not equally fortunate.

In a few cases enterprising employers themselves provide educational facilities during working hours, or make arrangements for workers to attend classes elsewhere. But in many others the matter is ignored, with the result that a boy entering works at an age of 14 may, by the time he reaches 18 years, actually receive higher wages than the boy who has devoted the intervening years to his education.

The response to the measures taken by educational authorities thus depends very greatly on the attitude of employers who, it is to be hoped, will value the services of the better educated youth, and see that he does not suffer but on the contrary receives special encouragement.

Scientific Darkening of the Streets.

On pp. 365—377 we give an account of the proceedings at the last meeting of the Illuminating Engineering Society. The address delivered by the Hon. Secretary dealt mainly with two important topical questions —the exercise of economy in lighting during war time, and the present darkening of the streets.

The authorities have been impressing on the public the need of economies in the use of the national coal supply. On the placards we observe the instructions "Don't waste coal, gas, or electric light," a direction which should meet with general approval and one which the Illuminating Engineering Society has endorsed on general grounds even in times of peace. But it is shown that it is equally important, in order that this recommendation may be effectively carried out, that the public should be educated to appreciate how economies should be judiciously executed. Light is a necessity to the carrying on of modern business and an indiscriminate diminution in the amount of illumination would react prejudicially on industrial operations, leading to increased accidents, spoiled work and diminished output. The right form of ecomony is to avoid improper use of light and here the Illuminating Engineering Society, whose services as an educational medium are recognised by many Authorities, could be of assistance.

The progressive increase in the number of street-accidents since the outbreak of war was discussed in a recent editorial. But apart from this, the present diminution of lighting, by interfering with traffic during the busy hours, is a direct economic loss. These questions will no doubt receive the attention of the "Safety First" Council for London, on which the Illuminating Engineering Society is to be represented.

At present, it is generally agreed that in many areas there is little scientific method in the darkening arrangements, and the conditions prevailing in various districts are quite different. This is no doubt a consequence of the effort to comply with conflicting claims by different authorities urging respectively the claims of precautions against aircraft, economy, and the convenience of traffic. There is an urgent need for a central authority, acting under expert advice, and in a position to survey the problem of the darkening of the streets as a whole and decide upon the best way of meeting these apparently conflicting requirements.

One of the most striking defects of the present arrangements is the great contrast in light and shade resulting from the present methods of screening, Attention was called to this matter at a meeting of the Society in November, 1914, shortly after the lighting restrictions were first introduced. Now, we understand, some experiments are being made with a view to securing greater uniformity of illumination. In addition the question must arise whether at the present stage experience justifies such an extreme diminution in illumination.

The whole problem is one on which expert assistance is badly needed, and we believe that the Illuminating Engineering Society, representing as it does all the different aspects of lighting, could do useful work if greater advantage were taken of their services by the Authorities concerned.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

SOME EVENTS DURING THE VACATION, WITH SPECIAL REFERENCE TO WAR ECONOMIES IN LIGHTING.

(Address delivered at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, at 5 p.m. on Friday, December 15th.)

A meeting of the Society took place as stated above on Friday, December 15th, at 5 o'clock. In the unavoidable absence of the Chairman of Council (Mr. F. W. Goodenough), Mr. W. C. CLINTON presided.

The minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of new applicants for membership as follows :—

Chandler, D	South Metropolitan Gas Co., Old Kent Road, S.E.
Phillips, T. B.	,, ,, ...
Oxley, W. B.	,, ,, ...
Torry, W. R.	,, ,, ...
Winter, B. F.	,, ,, ...
Walford, H. H.	Manager of the heat-resisting glass globe department, Messrs. Chance Bros. and Co., Glass Works, near BIRMINGHAM.

The CHAIRMAN then called upon Mr. L. Gaster to deliver his address on "Some Events during the Vacation, with special reference to War Economies in Lighting."

Before proceeding to the subject proper of his address Mr. GASTER made a special reference to the great loss which the Society had sustained in the death of its first President, Professor Silvanus P. Thompson, which occurred shortly after the Annual Meeting in May. In this connection Mr. GASTER read a letter from Mr. F. W. GOODENOUGH, who, after explaining that he was unavoidably prevented from being present at the meeting owing to special war work, added :—

> I should like to associate myself as Chairman of the Council, and also in my personal capacity, with the tribute paid in the address which you are giving this evening to the late Professor

Silvanus Thompson. His death is a very grievous loss to the Society, to which he always gave such ready and peculiarly valuable assistance, and to everyone who had the privilege of counting him amongst their friends.

We shall sadly miss his versatile and brilliant personality at the meetings of the Illuminating Engineering Society. It might well be said of him in that connection that he never touched upon any subject without contributing something original to its illumination.

Continuing, Mr. GASTER said that the Society had been honoured by a special message of sympathy from the Electrotechnical Section of the Société Impériale Technique de Russie, of Russia, which was as follows :—

Société Impériale
Technique de Russie,
Petrograd.
Panteleimonskaja, 2.
Section Electrotechnique.

To the
Illuminating Engineering
Society,
London.
4/17th November 1916.
No. 860.

GENTLEMEN,

The Electrotechnical Section of the Russian Imperial Technical Society has learned with profound regret of the death of the highly distinguished President of the Illuminating Engineering Society—the eminent Professor Silvanus P. Thompson, who was as well known and admired by Russian electricians as by those of the rest of the world.

On account of the cessation of meetings during the summer time, it is only to-day that the Electrotechnical Section has had the opportunity to express its most sincere sympathy with you, as with the City and Guilds Technical College and with the various British learned societies in the great loss you have sustained by the death of Professor Thompson.

We may add that, on receipt of the sad news, the members of the Electrotechnical Section honoured the memory of the late Professor by standing.

Wishing to your Society a continued and increasing prosperity,

We are, Gentlemen,
Yours very truly,
(Signed) Professor P. OSSADTCHY,
President of the Section.
,, D. MEISEL,
Secretary.

He need not say that this reference to the great qualities of the late Professor Thompson would be very much appreciated by the members of the Society. A tribute to Professor Thompson's great services to science was also paid in the official organ of the Society shortly after his death, and at the service immediately preceding the funeral the Society was officially represented.

Mr. L. Gaster then proceeded to deliver his address, which will be found on pp. 367—374.

In the subsequent discussion Mr. H. E. BLAIN (Operating Manager of the London General Omnibus Co., Ltd.), Mr. F. W. WILLCOX, Mr. A. CUNNINGTON, Mr. S. R. MULLARD, Mr. M. WYLD (Electrical Engineer to the Hampstead Borough Council), and Mr. J. S. DOW took part.

Mr. L. GASTER briefly replied and a vote of thanks to him for his address terminated the proceedings, the Chairman announcing that at the next meeting, to be held in January, there would be a discussion on "The Lumen as a Basis of Measurement of the Illuminating Power of Lamps."

LIGHTING CONDITIONS IN SHEFFIELD.

In view of the references in the discussion at the last meeting of the Illuminating Engineering Society on December 15th to the darkening of the streets, it is interesting to notice that the same question was debated at a meeting of the Sheffield City Council on the 13th. Mr. W. L. Angell stated that an order was being prepared prohibiting the use of flash-lamps after an air-raid siren had sounded, and the indiscriminate use of such lamps was deprecated.

Sir William Clegg said that in the three months ending December 11th, 1915, 11 men, no women and four children had been knocked down by trams; the corresponding figures for the period ending December 11th, 1915, were much greater, namely, 42 men, six women and two children, and seven cases proved fatal.

Dr. W. H. Fordham said the prevailing conditions were a source of danger. Other cities and towns were taking steps to relieve the darkness. He suggested special electric lighting at dangerous corners, which could be automatically extinguished on receipt of an alarm.

SOME EVENTS DURING THE VACATION, WITH SPECIAL REFERENCE TO WAR ECONOMIES IN LIGHTING.

BY L. GASTER.

(Honorary Secretary of the Illuminating Engineering Society.)

(Address delivered at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Friday, December 15th.)

IT is customary for the Hon. Secretary, at the opening meeting of the Session, to give an account of progress during the Vacation. In the past, on such occasions, there have been references to the participation of the Society in various International Congresses. Now, unhappily, there is no such international co-operation to record. But a number of recent events illustrate very clearly that in the present times there are opportunities as fruitful as in times of peace—and possibly even more so—for the exertion of the influence of the Society.

Before proceeding with this address, it is my duty to mention the very sad loss that the Society has sustained in the death of Professor Silvanus P. Thompson, our President during the first four years of existence of the Society. At the Annual Meeting in May Professor Thompson presided with all his usual enthusiasm and charm. His death, which occurred only a few days afterwards, came as a painful shock. A tribute to Professor Thompson's noble personality and distinguished abilities was paid in the notice that appeared in the official organ of the Society after his death.* It is sufficient now to say that we owe him a debt of gratitude we never can forget, and that his memory will be preserved so long as the Society exists.

Development of Illuminating Engineering in the United States.

In common with all other scientific societies our numbers have been affected by the withdrawal, either for service with the Colours or for other special war work, of members whose services would have been very welcome at the present juncture, and the whole trend of circumstances is directing our activities into new fields.

Many aspects of lighting are necessarily in abeyance, but it is gratifying to see that in the United States illuminating engineering is making steady progress. At the recent Convention an interesting series of papers and reports was presented, and the Course of Lectures arranged at the Pennsylvania University will furnish a useful precedent for us in the future. Among other points of interest is the Report on Nomenclature and Units. This list of terms and symbols will require consideration in European countries. Of special interest is the decision taken to adopt the "lumen" as a measure of the illuminating power of all kinds of lamps—a matter which, it is hoped, will receive the attention of our Society early in the new year. Yet another indication of progress is the decision of two States, Pennsylvania and New Jersey, to adopt legislation on the illumination of factories, in which the intensity required for various purposes is specified. The requirements appear to be broadly in agreement with those of the Departmental Committee of the Home Office in this country.

In other directions, notably in connection with street and spectacular lighting, progress has also been made. The method of flood-lighting, according to which the faces of buildings or signs, &c., are completely illuminated by a projected beam from a concealed source, appears to be coming popular. This method formed an important feature in the highly novel lighting devices employed at the Panama-Pacific Exhibition.

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* *Illuminating Engineer*, June, 1916, pp. 145-146.

We in England are at present debarred from the development of the artistic and decorative sides of exterior lighting, but, with a view to the future, it is well to make note of the new methods that are being introduced elsewhere.

In other directions there are developments now taking place which may have a profound influence in the future. We see everywhere tendencies towards co-operation, and, while some of these are only indirectly associated with illumination, they suggest possibilities of similar action in our own sphere.

The movement towards economy in fuel has led to many new experiments being tried. In his address to the deputation from the Board of Scientific Societies on December 1st Lord Crewe referred to an extensive survey now being made of the coal-fields in this country, with a view to ascertaining the basis on which they can be most economically utilised. The steps taken towards the linking up of gas and electric supply stations in various districts illustrate the change in attitude towards co-operation.

The present circumstances have also led to various forms of co-operation between gas and electrical supply. A number of authorities already supply gas and electricity in this country. In a recent Paper before the North British Association of Gas Managers, Mr. J. W. Napier gave an account of the very favourable experience of the authorities at Alloa where gas-driven electric generators are in use. The question of the best method of applying gas for the production of electricity, whether in the form of gas-engines or gas-heated boilers, hardly falls within our province. But the consideration of such problems may, we will hope, lead to fuller co-operation in the lighting field.

The position was summed up by Dr. Charles Carpenter at the meeting of the South Metropolitan Gas Co. last August, when he said :—

> "I do not know whether the policy adopted by Parliament of putting suppliers of gaseous and electric energy into competition has not had its day ; it may have. If one were to begin again, one would not do what one is doing to-day, viz., put up a large station to produce electric energy and another for gaseous energy. We should look to see whether these supplies should be undertaken separately, or whether there was not a great deal to be said on the point of economical working for running them together."

Daylight Saving.

One of the most noteworthy and revolutionary changes made, largely with a view to saving in fuel, is the Summer Time Act, generally known as "Daylight Saving Act," which came into force for the period from May 21st until October 1st in the present year. The effect on supply companies naturally varies much, according to the locality and the percentage of gas or electricity used respectively for lighting and fuel. In purely residential districts the diminution in output has been considerable. In Ealing, for example, it is stated to have been as much as 23 per cent., and other companies similarly affected have remarked that the Act ought to be termed the "Artificial Light Saving Act"! According to some figures recently given by Mr. A. E. Mackenzie before the Manchester Local Section of the Institution of Electrical Engineers, the saving in the purely residential district of that city was 13 per cent., but in the industrial districts there has been, since the Act was passed, an actual increase of 8 per cent. Taking the entire field of supply, the saving is of the order of 1—1¼ per cent. only, but even this is estimated to have led to an economy, in Manchester, of 400—600 tons of coal in the course of a year.

It would be most instructive if a complete survey of the effect throughout the country could be made, so that the resultant approximate actual saving in fuel could be estimated. The measure has been carried out with relatively little inconvenience, and may be permanently adopted after the war. At the present time, therefore, we should be prepared by gaining as full information of its effects as possible. Such an inquiry should not be confined to the actual fuel saving. It would be useful to ascertain if the change in habits of the people had been on the whole beneficial, and the effect of the measure on conditions of work in factories and offices. If it could be shown that the percentage of absentees through sickness had been materially diminished, this in itself would be a most important result, which would no doubt influence future decisions regarding premises into which the access of daylight is always deficient.

Associated with such an inquiry, again, is the whole question of the design of buildings with a view to maximum admission of natural light, and the comparative value of the various devices for improving the light in existing buildings (the use of prismatic glass, mirrors, &c.). As a measure of economy such devices, which prolong the hours during which artificial light is not needed, deserve much more scientific study than they have yet received in this country. These problems have an important relation to the work of the Committee of the Society on Natural Lighting in Schools, which was summarised in a Report issued shortly before the war, but has not since been carried further owing to lack of funds.

Mr. F. W. Willcox, in a recent letter to the *Illuminating Engineer* and other journals, has pointed out the need for an accurate comparison of the initial cost of making special provision for daylight in buildings, such as specially designed windows, and the consequent extra internal heating to maintain the correct temperature. An equally important matter is the diminution in daylight caused by the practice of obscuring skylights, &c., in order to comply with the lighting regulations. If it could be shown—what is probably the case—that the cost of providing efficient blinds, which could be drawn down in the evening and released in the day, was small in comparison with the running saving in artificial light so caused, this in itself would be an important result.

Economy in Artificial Light.

I come next to the question of economy in artificial light. The national importance of economising in fuel supplies has led the Board of Trade to issue circulars requesting consumers to diminish their consumption of gas and electricity for lighting, and inviting gas and electrical supply companies to co-operate in bringing about a 10 per cent. reduction. This matter was referred to in a recent editorial in the *Illuminating Engineer*.

It was stated then, what I am sure will meet with general agreement, that judicious economy in lighting, by which is meant prevention of the waste of light, and its application in practice in the most efficient manner, is one of the main objects of our Society. The advice widely placarded on the official notices throughout London—"Don't Waste Coal, Gas, or Electric Light"—meets with our full approval.

It is, however, necessary to supplement this advice by more detailed instructions as to how this waste can be avoided; and here our Society, which is constantly engaged in studying the proper methods of using light, is already doing national service. If the advice contained in the little pamphlet issued in 1913, entitled "Light and Illumination: their Use and Misuse," were generally followed a very large saving, accompanied by an improvement in the conditions of illumination, would be at once secured.

On the other hand, we have abundant evidence that the mere diminution of illumination, in cases where it is even at present insufficient for the purpose in view, is false economy. I have so frequently referred to the conclusions of the Home Office Report on Factory Lighting that good illumination is essential in factories and workshops, and that defective illumination leads to diminished output, spoiled work, and an increased number of accidents, that it seems hardly necessary to go over this ground again. I should like to mention, however, that these conclusions are strongly endorsed in the series of bulletins issued by the Committee on the Health of Munition Workers during the present year, particularly in No. 9 relating to Ventilation and Lighting of Munition Factories, and No. 15 (just issued) on the Effect of Industrial Conditions on Eyesight. No one, at the present moment, would think of handicapping our munition factories by restricting the supply of gas or electricity, either for power or for lighting, and the same applies to all productive work, both from the economic and hygienic standpoints.

A well-considered scheme of economy, therefore, can be made effective only through the systematic education of people to appreciate the proper use of light, and the Authorities would greatly assist the objects they have in view if they were to make use of this Society to prepare definite instructions on the subject to various classes of the community.

I may say that I have reason to believe that suggestions from us in the proper quarter would receive sympathetic consideration.

The education of the public as to what constitutes good lighting is a most important duty at the present time; and the technical press, which has so widely noticed our work since the commencement of the illuminating engineering movement, can do good service by keeping this matter constantly before the notice of their readers.

Meantime we have before us every day many examples of wasted light. We see lamps in shop-windows shrouded with coloured paper or obscuring lacquer so that a mere fraction of the light produced is allowed to penetrate through the screen and carry out any useful purpose. In interiors we see old and wasteful types of lamps still employed, or lamps used without any adequate form of shade or reflector, throwing a large part of the light where it is not required.

One difficulty which one meets in making economies is that of obtaining a proper supply of the best types of reflectors. The shortage is presumably due largely to the exceptional demands of munition factories, and to limitations in manufacturing facilities or material. Some members may be able to make suggestions on this point. It may be that this is a case in which we have to submit to present inconveniences, but it should be clearly understood that this is in no sense an economy. The cost of installing proper lighting appliances is small in comparison with the saving over a number of years in gas or electric consumption, not to mention the effect of unsatisfactory lighting on the output and quality of work.

Anything that can be done to encourage the development of lighting appliances of which we are lacking would be in the nature of an investment, since the life of such appliances is certainly much in excess of the lamps with which they are used. It would be interesting if makers could give approximate particulars of the life of reflectors of various kinds under average conditions; if they would state what can and is being done to collect and renovate reflectors, which, on account of surface deterioration, would otherwise be scrapped; and what other available materials could be suggested from which useful shades for temporary use could be made.

Assuming the need for economy, we are still in want of more definite information on the intensities of illumination actually required for various processes. This point was discussed at the time of the issue of the Home Office Report, and it will be recalled that in the American Code on Factory Lighting a rough classification of the illumination needed for safety and convenience, and for rough and fine manufacturing operations, was attempted.

So far, however, there has not been an exhaustive scientific investigation, based on actual results achieved with varying amounts of illumination. It is common knowledge that, with the introduction of more powerful lamps during the last ten years, the standard of illumination in interiors has steadily risen. There is good ground for thinking that this progressive change is well justified, and that the order of illumination prevailing in the days of carbon filament electric lamps and flat flame gas burners was often too low for modern strenuous work. In many instances it was certainly under a foot-candle.

Yet, from the standpoint of economy, it would be very important to determine the approximate upper limits, beyond which no gain in output or quality of work is to be obtained. A most instructive experiment is being conducted by the Commonwealth Edison Co. in the United States. A factory is being lighted in accordance with the best modern practice, and arrangements are being made for increasing at will the illumination to three times its present value. The experiment will be carried on for at least four months, the two methods of lighting being used alternately at intervals of a month, and a careful check of the output and quality of work kept throughout the entire period.

Now the Committee on the Health of Munition Workers has been carrying out many detailed investigations into the effect on output in munition factories of changing hours of work ; and similar researches undertaken in France, and described in the Chadwick Lectures recently delivered by Professor William Stirling, showed beyond doubt that if the hours of work are increased past a certain point the output first becomes stationary and ultimately falls off.

Illuminating engineering in relation to factories should be regarded as an important branch of the admirable "Welfare Work" carried out under the Ministry of Munitions, with which it has much in common. From the commencement of the movement we have regarded illumination as a necessity in modern life, and inquiry into its proper use as a public service. This idea was emphasised in the closing words of Professor Silvanus Thompson's Inaugural Address to the Society in 1909. We have found, too, as those engaged in the Welfare Movement have found, the necessity for patient education of public opinion through our meetings and through the scientific and technical press. It would be most instructive if, while detailed investigations into other variations in conditions affecting the health and efficiency of munition workers are being made, the influence of changing conditions of lighting could also be studied.

Lighting Conditions in the Streets.

I come now to another aspect of economy in lighting, namely, the diminished illumination in the streets. I wish to make it clear, as I did when this matter was first mentioned at the opening meeting of the Society in the autumn of 1914, that we are all willing to abide loyally by any conditions demanded in the interests of the safety of the country, and I do not mean to discuss this matter in relation to precautions which the Authorities consider necessary with a view to minimising the danger from hostile aircraft.

At the same time we cannot help being conscious that, if the assistance of those who have made a study of illumination for years were more effectively utilised, it might be possible to improve on the present arrangements in many respects—to make economies that would be very desirable at the present moment, and to provide conditions of illumination which, while meeting the views of the Authorities, would make the streets more tolerable for traffic and pedestrians.

When the diminution in illumination was first undertaken we offered our services to the Authorities. Subsequently, early in 1915, a Joint Committee was formed with a view to aiding the Authorities in this matter, and we are still anxious to be of assistance. Two years have elapsed, and there is now opportunity to judge the effect of these lighting conditions. One fact that has been strikingly brought out is the increase in the number of accidents due to motor vehicles which, for the years 1913 to the present time, were stated in the House of Commons, in reply to a question by Mr. Gilbert, to be as follows :

Year.	Total number of Fatal Accidents in the London Metropolitan Police District, caused by motor vehicles of all kinds.	Total number of Non-fatal Accidents in the London Metropolitan Police District, caused by motor vehicles of all kinds.
1913*	424	13,153
1914	493	14,638
1915	666	16,366
1916 to Oct. 31st ..	509	11,827

*Taken from the Returns on Street Accidents caused by vehicles during 1913, presented to the House of Commons, February 26th, 1914.

In an Editorial in the last number of the *Illuminating Engineer*,* it is pointed out that this increase has taken place in spite of a number of factors which should tend to diminish accidents, such as the diminution in the number of people and vehicles in the streets, the slower speed of traffic, the greater care exercised by drivers and pedestrians, and the tendency to greater sobriety since the outbreak of war.

The relation between diminished illumination and accidents, therefore, deserves careful study, and the following additional information would furnish useful data for drawing conclusions on this matter:—

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* *Illuminating Engineer*, Nov., 1916, p. 334.

(1) The returns of the accidents during *each month* of the period referred to above.

(2) The respective numbers of accidents in each month during the day, and between sunset and sunrise.

(3) The dates at which further restrictions in lighting have been introduced.

(4) The approximate figures for the number of licensed motor vehicles, tramcars, &c., plying in London in each month.

(5) The dates at which restrictions, if any, in the speed of such vehicles, have been introduced.

The importance of the matter was emphasised at the Conference called by the London General Omnibus Co. on Friday, December 1st, with a view to forming a "Safety First" Campaign Council for the Metropolitan area. Mr. Blain, the Operating Manager of the London General Omnibus Co. and the originator of the Conference, explains that the movement had its origin in a general desire to promote safety in the streets even before the present darkening took place. The present conditions, however, make the movement especially welcome, and it is not surprising that at the meeting most of the speakers referred to the anomalies in the treatment of lighting in different districts.

There are many different aspects of the subject to be considered. In addition to the question of accidents, there is the choice of methods of dimming the lights which will waste as little gas and electricity a possible. There is also the question of accidents, referred to above. And there is also the very important consideration that the mere slowing down of traffic (in some streets to a walking pace) is, especially at busy times of the day, a great economic loss.

The recent fog in London, and its attendant inconveniences, led to the lighting conditions being much discussed in the Press; and many suggestions, more or less practicable, have been made, for example, that two alternative systems of lighting should be provided so that in the event of a fog the illumination can be temporarily increased, the provision of special red lamps on refuges, and the more general whitening of the kerbs and other obstacles.

It is evident, however, that the greatest measure for the safety of the streets would be the more scientific darkening of the lights. One undesirable feature of the present arrangements, to which attention was called in the discussion of the Society in 1914, is the extreme "patchiness" and uneven distribution of light, giving rise to severe contrasts of light and darkness. There seems reason to believe that this inconvenient effect has not been deliberately sought for any purpose, and that it is merely the accidental result of the crude methods of shielding the lights now being employed. One of the first points to receive attention in a scientific inquiry would doubtless be the elimination of these severe contrasts in light and shade, which are distracting alike to drivers and pedestrians, and are probably not desirable, as forming distinct marks on the roads when viewed from above. The great variety in method prevailing in different districts apparently arises through the fact that a number of different authorities are concerned with the matter, whose directions are often more or less conflicting. In addition, it would appear from the results that the actual measures taken are often decided by people who have little experience of lighting problems, and do not appreciate the great difference in convenience occasioned by apparently small variations in procedure in dealing with public lamps.

At the commencement of this address I referred to the many unprecedented "linking up" measures, many of which would have been considered impracticable in peace time. Now that the darkening of London has been experienced for over two years, is it not time for a comprehensive inquiry to be made, and for the establishment of a central authority to deal with the matter, taking into account *all* the various aspects of the matter, and bringing about greater uniformity in the measures taken throughout London and possibly throughout the entire country? I believe that in this way it would be possible, not only to get better results from the standpoint of the public safety, but to make a very considerable saving in gas and electric consumption. Many of the present methods, which involve darkening almost the entire surface of the globe of a powerful lamp, are most unscientific and uneconomical, and at present there is apparently no body whose duty it is to see that better methods are adopted.

Gas and electric supply companies are, to a great extent, tied by their existing contracts, and neither they nor the Borough Councils are inclined to embark on rearrangements of lighting systems which may afterwards be vetoed. They are also perplexed by their efforts to meet the wishes of various authorities, some of whom consider the interests of traffic, others economy in lighting, others only precautions against hostile aircraft, but none supplying a definite specification stating how *all* these requirements can be most economically and efficiently met.

Our Society, which numbers amongst its members engineers concerned with both gas and electric supply, makers of lighting appliances, and experts in touch with various Government Departments, and which has made a special study of lighting problems and the compromise between different aspects of lighting which they involve, should be in a particularly favourable position to give assistance in this matter.

Research in the Lighting Industry.

In the final section of my address I wish to pass on to the general question of experimental research in illumination. It will be recalled that at the Annual Meeting of the Society last May the Research Committee presented a Report containing a list of investigations with which the Society might usefully occupy itself. In common with other scientific bodies, we are under the difficulty at present that many of our most able members are devoting their time to special researches for the Government. I would like to add that those of our members who are associated with Government Departments have shown every desire to encourage the scientific treatment of problems related to optics and illumination. In several cases efforts at improvement are being made, and if success in these directions is attained it will be very largely due to their enterprise. Apart from the efforts of individual members in such directions, two committees of the Society have been formed which are now at work on researches of this nature. We have also formed a committee to consider the question of illuminating glassware.

We feel, however, that we have still surplus energy to devote to other work of industrial importance. I have referred to a few researches of value, but there are many others, and I would remind members that we are always glad to hear suggestions as to problems that deserve study.

One of the most encouraging signs during the past two years has been the growing recognition of the need for scientific and systematised research, and we appear now to have reached a stage where investigations of value will receive sympathetic consideration from the Government, which is in a much better position to give practical support.

The formation of the Committee of the Privy Council for Scientific and Industrial Research was a most important step, which has already led to various industrial researches being undertaken. The statement made by Lord Crewe before the deputation from the Board of Scientific Societies on December 1st seems to open the way for much greater developments. Some of the most important points in his statement are :—

(1) The conversion of the Committee on Scientific and Industrial Research into a separate Department, established by Royal Charter under the title of the Imperial Trust for the Encouragement of Scientific and Industrial Research.

(2) The allocation to the Trust of a grant enabling four to five times the present expenditure on research to be made during the next five years.

(3) The announcement that money devoted by firms to research, under certain conditions, can be regarded as "working expenses," and is therefore free from income tax and excess profits tax.

It seems to me, therefore, that at the present moment there is before us a great opportunity for initiating research in the lighting industry. We have in view a number of specific researches with which to approach the Authorities.

In addition to this, in view of the magnitude of the lighting industry which we represent, and its vast national importance, there seems to me good ground for seeking to establish some body, working in co-operation with the Authorities, and having for its aim the development of the industry as a whole.

We see, in the new movement for the encouragement of research, an indication that better times are coming. It is for us to grasp the opportunity; for members to co-operate with us in undertaking researches, in interesting others, and spreading the movement to a wider circle; and for manufacturing concerns and gas and electric supply companies to recognise the value of the work that the Society is doing, and to give us fuller support in order that we may do greater things in the future

DISCUSSION.

The CHAIRMAN then called upon Mr. H. E. Blain, Operating Manager of the London General Omnibus Co., to open the discussion.

Mr. H. E. BLAIN said he was at present very much concerned with the Safety Campaign which had recently been inaugurated for London and from that point of view the street lighting problem was of very great interest. If the Society could put forward some scientific suggestions for the consideration of those dealing with the "Safety First" Campaign, they would be exceedingly useful. The whole difficulties in the streets at present were due to the anomalies to be found in different districts for the street lighting. In some places there was practically no lighting at all, whilst in others it was of comparatively great intensity having regard to the prevailing conditions. Certainly there was considerable room for greater science in dealing with the problem as a factor in reducing the large number of fatal accidents that were now taking place in the streets.

Mr. F. W. WILLCOX stated: There were two points that stood out in his view of the matter of the present street lighting arrangements. The first point was the question of the control of the lighting circuits. The present street lighting conditions in London justified serious criticism in the apparent neglect they show of utilising engineering methods in dealing with the problem. It had always seemed to him that some method of central station control should be provided so that the lighting could be dimmed when it was necessary to dim it and could be maintained at full brilliancy at all other times. Under present arrangements, the streets are dark at 3 or 4 o'clock in the afternoon just as much as they are at midnight. There certainly is no military necessity for the lights being darkened in the afternoon or early evening—the time of the day when there is a large amount of traffic and business requiring the best lighting facilities. If not with gas, then surely with electric lighting (considering the readiness with which electric current can be controlled and distributed) it should have been possible to have provided arrangements for separate circuits of supply for the street lamps, so that a very definite control could be maintained over the lighting, permitting the lights to be extinguished, dimmed or kept at full power in accordance with the conditions or time of the day. A series circuit with constant current regulation, of the pattern which is universally employed in the United States and Canada for street lighting, would have made it a simple matter to have operated separate circuits of street lighting lamps of low or high power, which could be switched on from a central point and definitely controlled therefrom in any degree of dimness desired at any time, while leaving the full brilliancy of the lamps available for use at all other times. If on no other plan, something of a temporary arrangement might have been adopted, employing overhead cables or wires strung on wooden posts placed along the curbing for low candlepower lamps, connected to and regulated from the central station. Such a system of "marker" lighting would have made it very safe for street traffic and for pedestrians.

The second point was the neglect of scientific methods of redistribution of the light under the reduction of light regulations. It certainly was an unfortunate omission on the part of the authorities not to utilise the aid which the Illuminating Engineering Society could have offered in dealing with this problem of light distribution. Apparently the whole problem was dealt with in such a hurry and in the expectation that the war would not continue for a long period, and that, therefore, any arrangements would only be temporary and need not be dealt with as a serious and definite problem in illumination. The failure to utilise Illuminating Engineering principles has resulted in a very unsatisfactory condition of illumination as everyone knows. The eye is an adaptable instrument which can work satisfactorily under various degrees of illumination so long as the illumination be uniform. The main problem therefore in dimming and reducing the light in the streets was one of ensuring uniformity of light with the reduction of intensity.

If this had been done (and it could have been done with any real engineering consideration of the question) the dangers and difficulties of street travel would not have been seriously increased. It is the extreme patchy condition of lighting with bright spots, alternating with absolutely black spots, glaring lights and then intervals of absolute darkness, that is responsible for the present troubles with the darkened lights of London.

He would not attempt to labour these points further but only desired to point out that the engineering factors involved in the question of proper light distribution arrangements and the central control of the lighting were well known, and that it was merely a question of applying such engineering arrangements and adaptations to the solution of the problem.

Mr. A. Cunnington agreed that something on the lines suggested by Mr. Willcox ought to be done. There was a simple solution of the difficulty in districts where the lighting had been reduced by switching out every alternate lamp and darkening the globes of those in use. In such cases it was quite feasible to fit lower candlepower lamps in the globes not used, and to switch them on in emergency, at the same time switching out the other lamps.

At Waterloo Station that scheme had been adopted. Previous to the war there were two lamp circuits on all the platforms, but during the war they had had to cut down the ordinary lighting to a half so that one circuit was turned out. Recently the circuit that had been out of use had been equipped with low candlepower lamps and the authorities had given permission to use the full power lamps at ordinary times, provided that these were switched off and the low candlepower lamps brought into use when the usual message came through that there was the likelihood of an air raid. That seemed a feasible solution of the street lighting problem wherever lamps were controlled from a distance, and it would not be difficult or costly to carry out.

An instance that came under his notice recently showed what economies could be made by the use of blinds instead of permanently darkening windows. A skylight had been darkened early in the war, the result being that a large amount of artificial lighting had to be used during the daytime. It was found that by cleaning the paint off the skylight and substituting blinds, the cost of the blinds was counterbalanced in ten weeks by the saving in artificial lighting.

A question just touched upon by Mr. Gaster was that of reflectors. The difficulty of getting them just now had induced him to consider the question of renovating old reflectors. On the South-Western Railway they had adopted extensively the plan of coating old reflectors with ordinary white enamel. Measurements of illumination under these renovated reflectors showed that it was within a few per cent. of the illumination with new reflectors. He admitted that they did not last so long as new ones but as an emergency device it was worth considering.

Mr. S. R. Mullard, speaking as one engaged in munition work, suggested that all possible means should be adopted to impress the importance of good lighting in such factories upon the authorities.

Mr. H. Wyld (Borough Electrical Engineer, Hampstead) said the reason why the street lighting had been dealt with as it was in London was because local authorities wished to avoid any possible expense at the present time; He agreed, however, that the present lighting arrangements in London were shameful. In the first instance the lighting authorities of London were asked to attend a meeting presided over by Sir Edward Henry on behalf of the police and the Admiralty, and they were told that they would receive instructions from the Admiralty through the police in their respective areas. These instructions had to be carried out whether the local authorities liked them or not. He had had constant trouble in trying to get a little better illumination in various parts of his borough where it was felt to be really necessary, such as street corners and important junctions, but nearly every time he put forward any suggestion the police inspector in charge of his district said that it was against the instructions and he could not allow any more light.

The effect of the Daylight Saving Act varied very much in different parts of the country, and in Hampstead it varied according to the size and nature of the premises. He had divided the district into four sorts of premises, from large houses to small flats, and the average of about a hundred examples showed that the accounts varied from about 15 per cent. to 32 per cent. At the same time he could not say that he had experienced anything like such a reduction on the output of the station. Indeed the output had only diminished by about 11 per cent., due to the increase in the heating and cooking load.

The wisdom of asking consumers to curtail their consumption naturally did not appeal to him as a supply station engineer, anxious though he was to obey all instructions.

Whilst he did put out a notice asking consumers to curtail their consumption, the Gas Company put a very ingenious notice on the back of their accounts suggesting that people should curtail their *lighting* consumption but increase their total consumption by using more gas for heating and cooking.

Mr. J. S. Dow endorsed what had been said regarding the need for eliminating waste of light, rather than aiming at an indiscriminate reduction.

As regards street lighting no one with any experience of lighting problems could help being struck by the utter lack of scientific method illustrated by the present conditions. This was the more regrettable because, even before the war, there was available a considerable amount of data, accumulated in connection with the inquiry into the Standard Street Lighting Specification, which would serve as a basis for a minimum standard of illumination essential in the interests of safety. It might be recalled that in main streets a minimum of 0·05 ft.-candles was suggested, in side streets 0·01 ft.-candles, and in country roads 0·001 ft.-candles. At present the illumination in London streets was usually unmeasurable by any ordinary form of photometer. Seeing that the brightness of moonlight is in the neighbourhood of 0·02 ft.-candles it was difficult to believe that a minimum value of say, 0·005 ft.-candles (*i.e.* half the value assigned to side streets before the war) would be a source of danger, while the preservation of even such a value as this would make all the difference to the convenience of traffic and pedestrians.

While the measurement of such low values certainly presented difficulties he thought it was by no means impracticable to devise a rough-and-ready form of test. No doubt the Society could take this up if there were a prospect that, after the work was done, the results would be utilised by the authorities.

The same divergence in practice that characterised street lighting was also met with in tramcars and motor vehicles. In some cases the illumination was almost enough to read by, and fares could be collected without very great difficulty. In other cases it was impossible in some seats to see a coin placed between the fingers. Seeing that fares were collected somehow this illumination might apparently be considered "sufficient for fares to be collected" as the Order stated. But the time taken by conductors in doing so was very much increased, and the present conditions were a constant source of delay and irritation to all concerned. He believed that by attacking the problem in a scientific way, instead of merely obscuring the lamps with lacquer, much better results could be secured.

All these difficulties arose through the fact that the people who gave instructions regarding lighting had little or no technical knowledge of the problem. A central authority, acting under expert advice, would be the means of saving a great deal of inconvenience and economic loss, and of securing conditions which provided a reasonable margin of safety.

In conclusion Mr. Dow read a passage from the Glossary in *Eclipse and Empire*, in which reference was made to the work of the Society and the need for development of the study of illumination on a much greater scale. There was a tremendous field for useful investigation open to a central body for research in illuminating engineering, such as Mr. Gaster had suggested in his paper.

Mr L. GASTER, replying to the discussion, thanked Mr Blain for his remarks and announced that, in response to the invitation conveyed to the Society through Mr. Blain, a representative of the Society had been appointed to serve on the London "Safety First" Council. In connection with the lighting of omnibusses it was interesting to notice that the experiments made in several cases promised a hopeful solution as the interior of the 'busses was reasonably well lighted and yet the light was prevented from being unduly transmitted into the street.

In regard to the street lighting he was glad to see that those who had joined in the discussion agreed that the present methods were unsatisfactory. When the alterations in lighting were first carried out, no one realised that the war would last as long as it had already done, and the improvised arrangements were regarded as purely temporary. But now when the question of economy and safety had become of such importance, it was surely desirable to profit by the experience of the past two years and to devise methods which were economical, satisfactory from the standpoint of protection against aircraft, and adequate in regard to traffic and safety. There was a general impression that the amount of illumination in the streets could by now be increased without prejudice to the requirements in respect of air-raids, but the proper distribution of the light was even more important.

He was interested in the suggestions of Mr. Willcox and Mr. Cunnington. The introduction of a constant current system might be considered a too radical departure at the present time, but a great deal could be done, even on existing circuits, by the substitution of smaller lamps, equipped with suitable reflectors. Some of the arrangements adopted by the railways, to which Mr. Cunnington had referred, were much better than those met with in the streets.

He was glad, also, to have Mr. Wyld's experience, as a Central Station Engineer, on the lighting in his locality. He quite recognised the difficulties of inducing the authorities to make improvements in the present circumstances but hoped that Mr. Wyld would persevere in his efforts. He believed, however, that the only hope of achieving a general improvement lay in the formation of a central controlling body, acting under expert advice, on the lines he had suggested.

The CHAIRMAN, in proposing the vote of thanks to Mr Gaster for his address, said he would like to couple with it a reference to Mr Gaster's unflagging efforts on behalf of the Society during the past year.

It was announced that the next meeting would be held in January when there would be a discussion on "The Lumen as a Basis of Measurement of the Illuminating Power of Lamps."

CENTRAL CONTROL OF GAS LIGHTING IN EDINBURGH.

On November 3rd members of the Edinburgh and Leith Gas Commissioners and of the Edinburgh Corporation Lighting Committee witnessed some experiments on the automatic control of street lamps in a section of Edinburgh by the Alder and Mackay apparatus.

At a conference held after the inspection it was pointed out that the application of this method would be very useful as a means of quick diminution or extinction of light in the event of a Zeppelin raid. In addition it is calculated that if the system were applied to 6,000 lamps in Edinburgh an annual saving of £2,500 to £3,000 would be made.

Mr. H. R. Kempe. Dr. S. A. Vasey. Mr. P. N. Hasluck (*Hon. Sec. and Treasurer of the Circle*). Mr. S. Rentell. Mr. Chambers Smith.
Mr. A. E. Haynes. Mr. H. Cooper. Mr. C. S. Phillips. Mr. J. L. Greaves. Mr. J. S. Dow. Mr. A. S. Jennings.

Photo by Ward, Manchester.

Mr. W. R. Cooper. Mr. L. Gaster. (*Chairman of the Circle.*) Prof. H. B. Dixon (*Chemical Department, Manchester University.*) Sir Henry Miers (*Vice-Chancellor of Manchester University*). Mr. Geo. Springfield (*Member Executive Committee Institute of Journalists.*) Mr. W. Palmer. Mr. A. T. Dale. Mr. E. Davis.

Photograph taken on the occasion of the Visit of the Circle of Scientific, Technical, and Trade Journalists to Manchester University, December 12th, 1916.

A VISIT TO THE UNIVERSITIES OF LIVERPOOL AND MANCHESTER.

(An account of a visit to the Universities of Liverpool and Manchester, and to various factories in the locality, by the Circle of Scientific, Technical, and Trade Journalists, December 10th—13th, 1916.)

It will be recalled that in previous issues of this Journal accounts were given of the visits paid by the Circle of Scientific, Technical, and Trade Journalists to the Imperial College of Science, London, and subsequently to the Universities of Leeds and Sheffield.*

A similar arrangement was next made by the Universities of Liverpool and Manchester, who invited the Circle, as the section of the Institute of Journalists chiefly interested in these matters, to form a party to visit these two cities on December 10th—13th. Throughout their stay the party were the guests of the Universities. This visit, like those mentioned above, should be most beneficial in enabling technical and scientific journalists to learn something more of the work carried on at the chief educational centres of the country, and to co-operate with them in bringing about a fuller public appreciation of the benefits of technical education and scientific and industrial research.

The party consisted of:—Mr. H. Cooper (*British Medical Journal*), Mr. W. R. Cooper (*Electrician*), Mr. A. T. Dale (*Plumber and Decorator*, &c.), Mr. E. Davis (*Chemical Trade Review and Chemical Engineer*, &c.), Mr. J. S. Dow, Mr. L. Gaster *† (Chairman of the Circle of Scientific, Technical, and Trade Journalists), Mr. J. L. Greaves† (*Stationery World*, &c.), Mr. A. E. Haynes (*Timber Trades Journal*, &c.), Mr. P. N. Hasluck*‡ (Hon. Sec. and Treasurer of the Circle of Scientific, Technical, and Trade Journalists), Mr. A. S. Jennings‡ (*Decorator*, &c.), Mr. Bernard Jones ‡ (*Building World*, &c.), Mr. H. R. Kempe (*Electrical Review*), Mr. W. Palmer‡ (*Laundry Journal*), Mr. S. C. Phillips† (*British Paper Maker*, &c.), Mr. H. E. Philpott (*Illustrated Carpenter and Builder*), Mr. S. Rentell (*Electricity*), Mr. H. Richardson (*The Engineer*), Mr. Chambers Smith (*Municipal Engineering*), Mr. Geo. Springfield * (Mem. Executive Committee of the Inst. of Journalists), and Dr. S. A. Vasey (*The Lancet*).

Among those who expressed their regret at being unable to join the party owing to pressure of editorial or other duties, &c., were :—Mr. E. J. P. Benn (*Hardwareman*, &c.), Mr. C. Chisholm (*System*), Mr. Gilbert Wood (*Architect and Contract Reporter*), Mr. T. C. Elder (*Engineering Review*), Dr. R. A. Gregory (*Nature*), Mr. Harold Jeans (*Iron and Coal Trades Review*), Mr. A. J. Mundella (Chairman of the London District of the Inst. of Journalists), Mr. A. E. Pendred (*The Engineer*), Mr. J. Meyjes (*Ironmonger*), Mr. W. A. Standring (*Motor Cycling* &c.), Mr. Sydney Walton (Welfare Dept., Ministry of Munitions of War), and Mr. H. W. Wills (*The Builder*).

Visit to Liverpool University.

The party arrived in Liverpool on the evening of December 10th. After dinner there was a reception at the Adelphi Hotel, where Professor Gonner (the Deputy Chairman of Senate of Liverpool University) and Mr. Carey (Registrar of the University) welcomed the party. Professor Gonner expressed the regret of the Vice-Chancellor at being unable to be present owing to indisposition, and gave an account of some of the chief features of the work of the University to be visited on the following day.

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* *Illum. Eng.*, June, 1916, p. 204.
Illum. Eng., October, 1916, pp. 314–322.

* Fellow of the Institute of Journalists.

† Representing the British Association of Trade and Technical Journals.

‡ Member of the Committee of the Circle of Scientific, Technical, and Trade Journalists.

Address by Professor Herdman:

On arrival at the University on Monday the party were met by Professor Herdman, who also expressed the regret of the Vice-Chancellor that he was unable to be present to welcome the representatives of the Press. At the University they all realised the great need for making their work known to a wider circle; they welcomed the co-operation of journalists in this direction, and hoped that such visits would be the means of promoting closer bonds between the Universities of the country and the scientific and technical press.

Proceeding, Professor Herdman referred to the important statement made by Lord Crewe to the deputation from the Board of Scientific Societies on December 1st. Pure and applied science were equally essential. No one could foresee the ultimate application of experimental work in pure science; and many of the great discoveries, such as those of Davy, Faraday, Galvani, Oersted, and others, were made without any ulterior motive or hope of reward.

In the Liverpool University both pure and applied science were represented. In addition, much of the work was of special utility to a great shipping and commercial centre like Liverpool. The School of Commerce was undertaken jointly by the City and the University, and the latter had organised courses of modern languages, including Russian, and a department for the study of geography—a subject that was now recognised to have great commercial importance.

In the Engineering Sections a great deal of work was being done for various Government Departments, and close co-ordination was maintained between the University and the various technical schools in the district. Courses for the training of munition workers had been organised.

In another direction, medicine and public health, the University's work was of considerable importance to the City of Liverpool. The School of Tropical Medicine had a direct bearing on the health of the city, in view of the constant arrival and departure of vessels to and from tropical countries, by which the germs of disease might easily be spread if proper precautions were not taken. The research work of this department had been of great benefit to pioneers in tropical districts, destined eventually to become the home of the white man. In the bacteriological departments work is also being done for the city in connection with the testing of foodstuffs, shell-fish, &c., and the detection of anthrax and other diseases of animals, and this laboratory is also recognised by the War Office as the centre for Liverpool and the adjacent district.

Dr. S. R. Vasey (*The Lancet*) made a few remarks on behalf of the visitors, who, he said, were gaining a valuable insight into the work of the leading Universities—work which marked the dawn of a new era in scientific and technical education.

Engineering Departments:

The visitors were then conducted over the Engineering Department of the University. In the section under Mr. J. Wemyss Anderson, attention was drawn to a series of experiments on belts, the vibrations of reciprocating engines, and combined stresses in steel. There is also a special plant for researches in hydraulics, and refrigeration has also been closely studied. In the Mechanical Engineering Department, under Professor Watkinson, a great deal of special work for the Ministry of Munitions is being carried on. This includes Lectures on the Manufacture of Shells, the Training of Munition Workers, Preparation of Gauges for Shells, and Tests of Materials, such as bronze, copper, and steel. It was particularly interesting to notice a number of men in khaki being trained on the premises for work in the R.A.F.C.

A conference is now being held at the University to consider technical education in the district. This matter, and also the question of research in connection with new types of machinery and new processes of interest to the mercantile marine, are being studied in connection with the needs of the great shipping industries of Liverpool.

In the department of Applied Electricity under Prof. W. E. Marchant, the visitors had their attention drawn to other researches undertaken for Government departments or in connection with industry. With the cooperation of the Electrical Engineer to the Liverpool Corporation a series of tests on buried copper-bitumen cables were in progress. We understand that these experiments are to continue for an entire year, but already useful data regarding the current-carrying capacity of such cables have been obtained.

Work on Magnet Steels is being done in connection with the Institution of Electrical Engineers Research Committee and in co-operation with Sir Robert Hadfield, a point of special interest being the bearing of such researches on the steel used in magnetos for aeroplanes.

We were much interested to see the Globe Photometer, constructed under Prof. Marchant's supervision, in operation. It will be recalled that an account of this apparatus was given by Prof. Marchant in his paper before the Illuminating Engineering Society in 1910.*

Address by Alderman Alsop (Chairman of the Liverpool Education Committee and Pro-Chancellor of the Liverpool University).

Following this inspection the visitors were entertained to lunch by the University, Alderman Alsop, who in the above functions represented both the University and the City of Liverpool, presiding.

Alderman Alsop gave a short address expressing a welcome to the visitors, in the course of which he showed the close relation of much of the University's work to the activities of Liverpool, although it had also a wider application.

It would be found that most of the Universities had a direct bearing on local industries. For example, Leeds and Manchester were interested in textile manufacture, while Birmingham and Sheffield had long been associated with engineering. In Liverpool, on the other hand, the chief interest was its shipping trade which made the city a great commercial centre. The University had therefore taken up such subjects as the teaching of languages, geography, history, and economics, which had great commercial importance.

The School of Tropical Medicine, again, had been a great aid to commerce, for the researches of the School had made it possible for white men to open up and live in tropical countries without undue loss of life through injury and disease. Chemistry was a subject of great industrial importance in view of the many chemical works established in the vicinity of Liverpool, though not in the city itself.

While meeting all these requirements the University had not overlooked its primary function of providing a liberal education. It had received from individual donors endowments to the value of over a million pounds and also had the support of the Treasury and the Board of Education and the City Council.

Mr. Leon Gaster, in responding for the visitors, said how glad they all were to have this opportunity of learning at first hand what the Universities were doing for science and its application to industry. One great benefit of such visits was the way in which their minds were opened to the practical utility of the most diverse subjects. Medicine for example, which was the subject of special study in Liverpool, had a direct relation to many great engineering triumphs, an instance being the great services which medical men had rendered in connection with the stamping out of malaria during the building of the Panama Canal.

Professor Herdman, who said a few words of welcome on behalf of the Senate, also drew attention to the close relation existing between the work of the University and the life of the City.

In the afternoon the visitors passed rapidly through other departments of the University, including those devoted to geography, tropical medicine, zoology, pathology and bacteriology, and organic chemistry.

Geography, as studied at the Liverpool University, is a more complex subject than many would suppose. Not only is map-making (a subject whose importance has been very vividly illustrated during the present war) studied, but the physical conditions prevailing in different sections of the globe, and the relation of geographical features to the commercial and historical development of nations are considered in their broadest aspects. One could not but be impressed with the great practical value of the subject treated in this way.

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* *Illum. Eng.*, January, 1911.

The School of Tropical Medicine :

At the School of Tropical Medicine, under Professor Stephens, the importance of studying climatic conditions in different countries was again illustrated. Not only are researches carried out on the behaviour of the microbes of malaria, sleeping sickness, and other tropical diseases, but the life-history of the parasites which are responsible for their dissemination, and the conditions of vegetation which favour the development of these parasites are studied in detail. Equally interesting was the inspection of a department in which, by means of models and specimens, the resemblance between the diseases contracted by men and animals was shown. The University possesses a School of Veterinary Science, whose work has been of distinct value to the Military Authorities, and the suggestion was thrown out that the organisation of a Hospital for the Treatment of Animal Diseases would be a welcome addition. In view of its commercial application to the development of livestock as well as its bearing on human health, such an enterprise would seem well worth consideration. At present, we understand, relatively little is known about the origin and treatment of many diseases from which animals suffer, and the losses involved in a single epidemic among cattle must often be considerable.

In the bacteriological department the researches into the study of cases of cerebro-spinal fever, dysentery, typhoid, &c., have a direct military value, and the examination of foodstuffs and of animals suspected of anthrax, tuberculosis, &c., have an obvious relation to public health.

Lastly, reference should be made to the very interesting department in which researches into subjects appertaining to the local sea-fishery industries are carried on. An interesting feature of this section of the work is the well-equipped museum. Reports are constantly received from the local stations on the estuary of the Mersey. This is another subject on which comparatively little is known at present and there are many fields for promising research.

After leaving the laboratories the visitors were entertained to tea at the University Club, where Professer Gonner and other professors were present. Mr. W. R. Cooper expressed the thanks of the visitors, and Prof. Gonner said a few words on behalf of the University.

The party then left for Manchester by an evening train.

Visit to Manchester University.

After arrival at the Midland Hotel, the Vice-Chancellor of the University, Sir Henry Miers, and Professor H. B. Dixon welcomed the visitors at an evening reception, and Mr. C. S. Phillips said a few words in reply.

Address by Vice-Chancellor :

The party were addressed at the University on Tuesday morning by Sir Henry Miers, who traced the progress of the University up to the present day. Originally the Owens College, the University of Manchester now forms part of the Federal Victoria University. In normal times there are about 1,600 students, but during the war the number has fallen to about 420. Most of the departments are actively engaged on war work, the testing of materials being undertaken in the Engineering Department, while in the chemical laboratories there are constant tests on explosive materials and on the products from neighbouring gas-works, from which toluene is extracted.

Sir Henry Miers also expressed his conviction of the importance of continuity in research in pure science, as well as the application of science to industry. Since the outbreak of war many steps in this direction had been taken, but there was still need of arousing amongst the manufacturers of the country a keener appreciation of the benefits of industrial research and the scientific and technical Press could render most valuable service in bringing this matter to their notice.

A visit was then paid, under the guidance of the Librarian, to the Christie Library, which now comprises about 146,000 volumes. The Library originated in a gift to the University of a collection by Mr. James Heywood in 1851. and since that date various other important collections, including that of the late Mr. R. C. Christie, formerly professor of history in the Owens College, who also bequeathed a sum of £10,000 for the equipment of the Library.

Visit to Chemistry, Physics, and Medical Departments :

Subsequently a tour was made through the Chemistry, Physics and Engineering Departments. A short lecture was delivered in the Chemical Department by Prof. H. B. Dixon, who gave an interesting account of his work on the structure of flames, showing a number of photographic films illustrating the nature of flames caused by explosions. An experiment on picric acid demonstrated the comparative safety of this material unless a detonating ingredient was present. Professor Sir Ernest Rutherford gave an account of the work carried on in the Physics Department, referring particularly to the testing of radium which is now of practical importance for many special purposes as an ingredient in luminous paints. In passing through the laboratories visitors were shown a very fine example of the arc spectrum of iron, obtained from a Rowland grating. In the Medical School a short address was given by Professor Elliot Smith on some of his work on shell-shock. It was explained how in many such cases the disturbed state of nerves and mind is not due to the effect of a particular shell but the cumulative result of strain. The condition of mind of a patient may be aggravated by recollection of some disturbing incident in his childhood; such an impression needs to be removed by the sympathetic and patient treatment of the physician, who endeavours to trace the source of anxiety and to show that it is unfounded. In the Electro-chemical Department the visitors were shown a magnesia crucible prepared in the laboratory. In view of the fact that magnesia melts at about 2800° C. the production of such a crucible is a remarkable feat. It is stated that the industry of fused silica was originated in this laboratory. A visit to the Museum completed the morning's programme.

The visitors were then entertained to lunch by the Mayor of Manchester, an interesting incident being the reception of Lieutenant (now Captain) Kelly, who had recently been awarded the V.C. and was present, with several relatives, at the luncheon.

In an address to the visitors, the Mayor expressed a welcome on behalf of the City, and emphasised the importance of technical education and research to the nation. Mr. L. Gaster responded for the visitors.

Mr. J. C. Maxwell Garnett, Principal of the Municipal School of Technology, then gave a brief account of the equipment and work of the School, which was to be visited in the afternoon.

Address by Mr. J. C. Maxwell Garnett :

The School of Technology, Mr. Garnett said, was founded in 1824 as the Manchester Mechanics Institution, but had since become a college of University rank. The present buildings were completed in 1903, and the annual cost of maintaining the College is about £50,000; this sum would have been much greater but for the generosity of industrial firms and private persons in founding scholarships and providing equipment.

One function of the School is to provide a university training suitable for men entering industrial employment and, so far as concerns this department of its work, the School is essentially a part of the University of Manchester.

For some years before the war the demand for trained students was exceeded by the supply, and after the war the demand is likely to become greater still. The future of the engineering and other industries will depend in no small degree upon the willingness of young Englishmen to subject themselves to mental discipline and undertake the strenuous study involved in a University course.

The conduct of industrial research. for the most part in co-operation with firms engaged in the industries of South-East Lancashire, forms an important section of the work of the School of Technology. A notable example of the new attitude towards research is furnished by the action of the Governing Body of the School in providing a number of research scholarships, each of the value of £100 a year; and in establishing a new department for post graduate study and research bearing upon the manu facture of intermediate products and finished dyestuffs from coal tar. The Governing Body has also decided to erect new laboratories for demonstration and research in connection with internal combustion engines, and engineering firms in the neighbourhood of Manchester have promised to equip the laboratories with engines to the value of £3,000.

The School is now doing important work in connection with the war, and there is hardly a department that is not doing work for the Admiralty, the War Office, the Munitions Inventions Department, the Board of Inventions, the Royal Aircraft Factory, the Ministry of Munitions or some other branch of the Government. Research work is in progress for others of the Allied Powers. Machines of a new type have been designed in the laboratories of the School and afterwards manufactured on a large scale in engineering works in the district and elsewhere. In co-operation with a Committee of the Manchester Association of Engineers, important experiments on tool-steel have been carried out. These experiments have already resulted in a considerable saving of steel and in increasing the pace at which shells and other munitions can be machined. When the war has been won the country will recognise how greatly the work done by the Universities has contributed to victory. Equally important in the industrial direction are the researches made possible by the liberal grants afforded by the Advisory Council to the Privy Council Committee on Scientific and Industrial Research.

In addition to the university courses there are part-time (mainly evening) classes conducted for those who are constantly engaged in industrial work. Professors find that the interchange of views with such men is of great benefit to their own consulting work, in keeping them abreast of developments.

The buildings and most of the equipment of the School of Technology belong to the citizens of Manchester, and the School has thus a very democratic form of government.

In conclusion, Principal Garnett expressed the hope that the visitors would enjoy their visit to Manchester, and that the visit would lead to still closer co-operation between the Universities and the industries of the country.

Visit to the Municipal School of Technology.

During the afternoon the visitors made a rapid inspection of the various departments of the School of Technology. It was naturally only possible to survey the arrangements in a very general manner, but all were struck by the excellent equipment and the very varied nature of the work carried on.

The electrical and engineering plant is probably equal to that of any other similar institution in this country. The plant supplies the entire lighting of the building and power can be quickly and easily obtained for research in any department. In the electrical laboratories a number of researches were being carried on, for example the visitors were shown an entire room devoted to high-tension tests on various insulating materials. The arrangements in the electrochemical laboratory were also very convenient, such devices as mechanical pulverisers being shown in operation. In the basement tempered steel was being produced from one of the latest gas furnaces, the temperature being controlled with an optical pyrometer. It was stated that very fine results from this furnace have already been obtained.

A very large area of the ground floor is given up to cotton-spinning and paper-making machinery. In the former section fabrics have been manufactured for aircraft and for other special war purposes. There is also a well-equipped department given up to printing. The programme handed to the visitors on arrival was printed on the premises on paper produced in the paper-making department, and the School undertakes the preparation of all its own stationery and literature.

In the chemical department research on dyestuffs is carried on, and visitors were shown a new insulating material obtained by chlorinating a solution of rubber in carbon tetrachloride. Experiments on the standardisation of rubber products is also in progress. An interesting feature introduced in the chemical laboratories is the partitioning off of a section of the room with glass, so as to form a private laboratory for the staff. In the case of advanced students it will be practicable for the staff to continue their own experiments and yet to be able to get in touch at once with any student in the main room who is in want of advice.

There are two lifts, one hydraulic and one electric—a desirable feature in such a large building.

Tea was served in the School, after which Mr. Gaster expressed the thanks of the visitors, and the Vice-Principal briefly replied.

Dinner and Reception at Manchester University.

In the evening the visitors were invited to a dinner and reception which took place at the University, Sir Henry Miers, the Vice-Chancellor, presiding. Councillor Simpson, in proposing the toast of the visitors, mentioned that he himself undertook a good deal of journalistic work, and therefore appreciated the services that the Press could render to science and industry. Mr. Leon Gaster and Mr. W. R. Cooper responded for the visitors, and a vote of thanks on their behalf was proposed by Mr. H. R. Kempe. Short addresses were also delivered by the Vice-Chancellor, Professors H. B. Dixon and Sir Ernest Rutherford, and Mr. J. C. M. Garnett (Principal of the School of Technology). All expressed the hope that through such visits the Press and the Universities would be brought into closer relations and that in the future there would be opportunities for constant interchange of views in order that new educational developments might speedily become known to the manufacturers of the country.

The dinner was followed by a short musical programme, kindly rendered by some of the students of the Academy of Music, which was greatly appreciated by the visitors.

Visits to Factories.

Works of the British Westinghouse Electrical and Manufacturing Co., Ltd.:

On Wednesday, December 13th, the morning was devoted to a visit to the works of the British Westinghouse Electrical and Manufacturing Co. In the space available it is quite impossible to do justice to the scale on which work is carried on. Visitors were equally impressed by the assembling of large generators on the ground floor, the extensive switch-gear department and the assembling, winding and testing of all sizes of transformers. In addition to the very large amount of electrical work going on the company has devoted a section of the works to the manufacture of large calibre shells, for which a number of lathes have been specially designed and manufactured on the spot since the outbreak of war. A great deal of fine work is also being done on shell-fuses and other parts.

In the research departments tests were in progress on the permeability of steels and on the period of break of switches, the arrangements for the latter experiments being particularly ingenious. We were informed that this department will be considerably extended in the near future.

One of the most interesting features of the work of this company is the training of employees, on which a short address was given by Mr. A. P. M. Fleming. It will be recalled that Mr. Fleming, who is an authority on industrial research and the training of apprentices, gave an address on this subject to the Circle earlier in the year. Visitors had an opportunity of seeing how his ideas are being carried into operation. One admirable feature of the training is that apprentices are not required to attend classes in the evening after a hard day's work in the shops. For most men the assimilation of information in these circumstances is quite impracticable. A regular course of instruction is given in a lecture theatre inside the works, and during working hours. The relation between theory and practice is thus very readily shown, and the men so trained can rise by degrees to the highest positions. The Company is already reaping the reward of their enlightened policy in this direction.

The Ford Motor Works:

In the afternoon a visit was paid to the works of the Ford Motor Co. at Trafford Park.

The feature in these works is the remarkable way in which every element in the car has been standardised, and the highly ingenious and complete use of automatic machinery.

The guiding principle adopted is for the work always to come to the operators instead of the latter having to move from place to place on their job. They remain in the same place, carry out the same operations day by day, and become experts on their particular process. The cars are assembled on a long moving chain, running the entire length of the factory. As the developing car gradually moves along each part is added at the appropriate point, and each element is tested while the work is in progress. Thus at one point the motors are being placed in position. A little further the steering apparatus is being added. Then the mud-guards are seen travelling on a subsidiary chain, being coated and dried in the process and arriving at their appropriate stage in the operations. A little further and the wheels come hopping down a gallery running crosswise. Two subsidiary railways feed in the hoods and fabric. Finally the complete car passes out into the yard where some ingeniously devised wheels below the pavement set the engine in motion. The driver then takes its place and the car is given a short trial run round the yard, after which, in the great majority of cases, it is ready to go out. Cars arrive at this stage at intervals of about 5 to 10 minutes, and as many as 150 have been produced in a day.

Passing through the works one was struck by the very orderly way in which each process is carried out, the free space round each machine, and the absence of "dumps" of unutilised material. The repair department is organised in a similar way.

At the conclusion of the visit a short account was given of the Welfare Work of the firm, which has many unique features. An exceptionally high wage is paid, and in addition workers receive a bonus after six months if their conduct during this period has been exemplary. There is a medical department on the premises to which any injured workman must at once report in the event of an accident. A careful record is kept of each operator's health and inquiries are at once instituted if he fails to present himself for work.

Such care, we believe, is amply repaid by results.

In conclusion it only remains to be said that everything possible was done to make the visit enjoyable and instructive. The party returned to London feeling that they had witnessed another important section of the valuable work being done at the leading Universities, and much impressed by the great commercial and industrial development of the two cities.

EDUCATION AND DEMOCRACY.

In his inaugural address to the Fifth Annual Conference of the Educational Association, which opened on January 2nd, Mr. A. L. Smith, Master of Balliol, emphasised three important reforms in education, namely, the continuation of education of children above the ages of 13 and 14, the need for improvement in the position and prospects of teachers, and the organisation of the scholarship system.

One of the most hopeful signs was that an interest in education was spreading to the working classes. Experience showed that better workmen were secured by education than by setting lads to work at an early age. If we were to repay the sacrifices of the Dominions by a true and closer union there must not be, in this federation of democracies, a democracy profoundly uneducated at the centre, and unless we made proper use of our opportunities now we should not be, in the true sense, victors in this war.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

ANOTHER MAZDA REVOLVING SHADE.

About a year ago **The British Thomson-Houston Co., Ltd.,** introduced an ingenious advertising novelty in the form of a revolving shade. This was intended for use with table, desk and other fittings in which the lamp holder is in an upright position. When the lamp was switched on, the shade rotated owing to an upward current of air heated by the lamp impinging upon a fan disc attached to the upper part of the coned shade and pivoted upon the tip of the lamp. This device could not, of course, be used with pendant lights, but the Company has now produced an adaptation of the design that permits of its attachment to plain pendants.

The accompanying illustration shows the appearance of the shade when in position. When the lamp is switched on, it illuminates the coloured shade, which immediately commences to revolve, the effect being both striking and attractive. If the adapted pendant be placed in a sunny position, its shade will rotate during the hours of sunlight without the lamp being lighted. The rapidity with which the shade revolves depends upon the velocity of the heated air current, so that the greater the wattage absorbed by the lamp the greater the speed attained.

Readers in the Trade can obtain these shades upon application to the Publicity Department, The British Thomson-Houston Co., Ltd., Mazda House, 77, Upper Thames Street, E.C., each shade being packed in a cardboard box suitable for sending through the post.

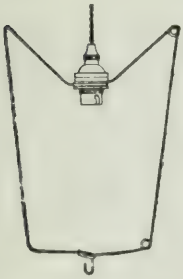

FIG. 1.
Wire frame, 1st position.

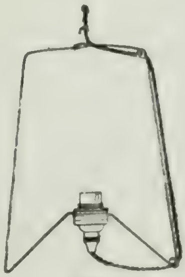

FIG. 2.
Wire frame reversed, ready to receive lamp and shade.

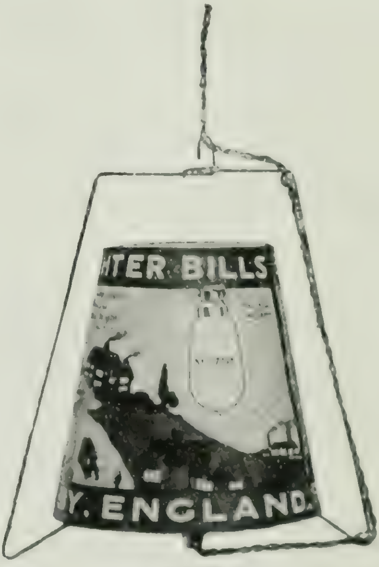

FIG. 3.
Mazda revolving shade complete.

REVIEW OF BOOK.

Journal of the British Science Guild (*Nov.* 1916).

The Journal of the British Science Guild for November last contains a number of interesting items including a Memorandum on the Relations which should exist in future between Science and the State, a Memorandum on the Encouragement of Teaching and Research in Science in British Universities, and a Report on Reforms necessary in National Education.

Attention is drawn to the great variation in the average salaries of Professor in the Faculty of Science at the chief Universities of the country. Manchester and Liverpool come first with £888 per annum and £853 per annum respectively; while Southampton and Aberystwyth come last with only £325 and £320 per annum. The remuneration of the Professors and facilities for instruction in science at the Universities and Colleges of South Wales are considered quite inadequate, and these institutions are urgently in need of further State assistance.

Other suggestions are:—(1) Temporary and Associate Professorships in state-aided Universities should cease and the title of "Regius Professor" involving the status and privileges of Civil Servants, under the Crown, should be conferred on Professors at such institutions. (2) The provision of an adequate scale of pensions for Professors. The Report on National Education is concluded by a long list of concrete suggestions, from which we take the following:—Employers to give reasonable facilities for young persons within the ages of 14 and 17 to attend suitably equipped Continuation Schools for at least six hours per week; "Leaving Certificates" at Primary and Secondary Schools to be instituted; Fuller coordination between technical institutions and the Universities to be established; Improved training of teachers and the placing of salaries, superannuation schemes and conditions of tenure on a more satisfactory basis.

LECTURES ON ILLUMINATING ENGINEERING.

We understand that reprints of the lectures on Illuminating Engineering recently delivered at the University of Pennsylvania, U.S.A., will be available early in the present year.

It is anticipated that the selling price of the bound volume will be in the neighbourhood of five dollars.

Applications for particulars should be addressed to Mr. Clarence L. Law, Irving Place and 15th Street, New York.

UNIVERSITY OF ILLINOIS.

New Ceramic Engineering Building.

We notice that a new building devoted to Ceramic Engineering has just been opened at the University of Illinois (U.S.A.).

The building occupies a ground area of 67 by 185 feet and costs approximately a quarter of a million dollars. It is intended for instruction and research on such materials as high grade brick, tiles, terra-cotta, cements, glassware and sanitary ware, &c., which form a very considerable American industry.

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Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

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This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

THE EFFECT OF INDUSTRIAL CONDITIONS ON EYESIGHT.

Bulletin No. 15, issued by the Committee on the Health of Munition Workers, draws attention to the prevalence of eye-trouble among munition workers, leading not only to personal suffering and inconvenience, but to serious loss of time and diminished output. Thus in the Coventry and Birmingham district alone it is estimated that 500—700 days' work are lost annually through such defects.

Among the causes of accidents are :—

(1) Injuries due to exposure to intense heat or industrial poisons.

(2) Accidents due to flying particles, &c.

(3) Eye-strain due to uncorrected errors of refraction or other causes.

Attention is drawn to the importance of ascertaining that operators engaged on fine work have sufficient acuteness of vision. Instances have come before the Committee of headaches and eye-strain resulting from (a) inadequate light, both natural and artificial ; (b) artificial light adequate in amount but so placed as to throw a glare on the eyes of the worker; and (c) employment of workers (whose eyesight is aided by suitable glasses) to carry out fine work without first testing their eyesight. Eye-strain, including headache, may be one manifestation of general fatigue and is likely to become marked when long hours are worked, night shifts are necessary, or when workers are under-nourished, anæmic, or of poor general physique.

In connection with the effects of poor illumination it is remarked :—

"The lighting of factories has so recently been dealt with in detail in the Report of the Committee on Lighting in Factories and Workshops that no further reference is here needed. But the question of supervision of the eyesight of workers employed on fine detail work calls for special comment." From one factory it is reported that "in contrasting the eye conditions found in the different workshops the worst effects were found in the fuse department where the fine process involved close attention. Here 8 per cent. of the workers had been obliged to obtain glasses since starting the work, 12 per cent. found sight difficult at night, another 7 per cent. complained of eye-strain, and 2 per cent. found eye-strain increasing in severity."

The Committee emphasise the importance of proper examination of eyesight, the prompt reporting of small injuries which, if not treated, may develop more seriously, and, where flying particles of steel or other metals are common, the use of appropriate eye-guards or goggles. A sketch of a suitable type of goggles is provided.

"Revue Generale de l'Electricite."

It is announced that from January 1st onwards *La Lumière électrique* and *La Revue électrique* will be combined in one journal, *La Revue Générale de l'Électricité*, published at 12, Place de Laborde, Paris.

The first number of the new journal contains an editorial summary of the programme of the new journal from the pen of Professor A. Blondel. British readers will wish the new journal every success.

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